Getting Started on a Science Fair Project

Helpful Guidelines & Examples

How do I find a good Science Fair idea?

- **What are YOU interested in?**
  Research your interests through science magazines such as Science News, Discover, Science Daily, etc.

- **Search Internet (some resources)**

100+ High School Science Fair Projects: Award-Winning Science Fair Project Topics for High Schoolers — Inspirit AI

List of Science Fair Ideas and Experiments You Can Do.

Browse Science Projects | Education.com

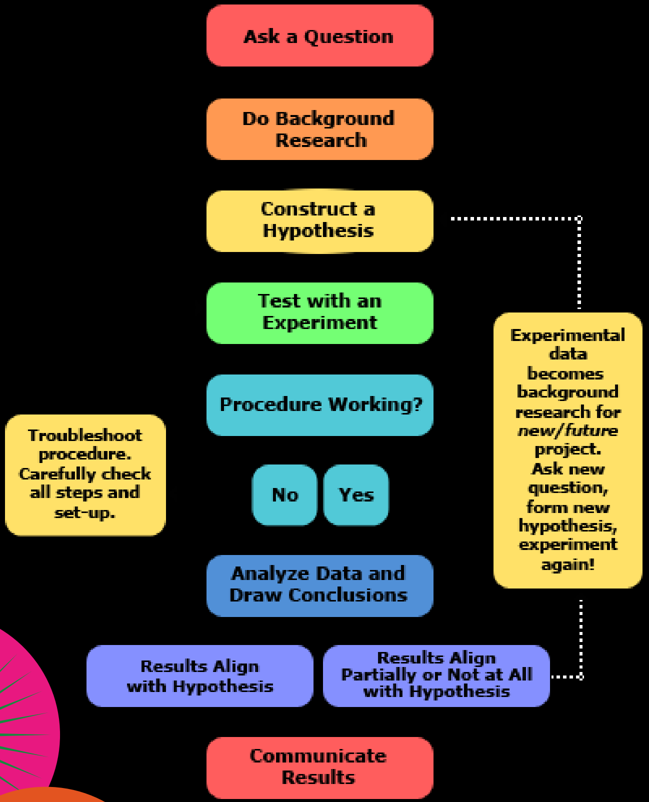
Classroom Resources - National Council of Teachers of Mathematics
Classroom Resources - National Council of Teachers of Mathematics

http://school.discoveryeducation.com/sciencefaircentral/ParentResources.html

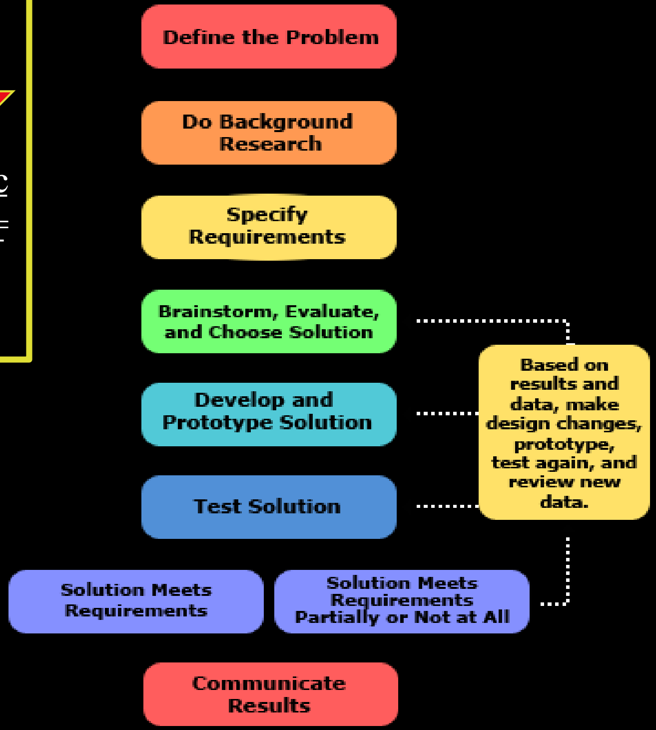
- **High School Level: Look at ISEF ONLINE abstracts by category: https://abstracts.societyforscience.org/**
  - **Search by category (forget other info; choose year)**

- **Look at the ISEF categories & choose the SMALLER categories (math, embedded systems, robotics, materials sciences, engineering mechanics, environmental, earth, etc..). https://www.societyforscience.org/isef/categories-and-subcategories/**

Experimental OR Engineering



Watch this 7.5 min. Video to learn the difference:
https://www.youtube.com/watch?v=uIV031bnmFA&ab_channel=ScienceBuddies



For more info…

https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-compare-scientific-method

Decide Which Type You are Interested in Doing

Experiment/Scientific Method	Engineering Design Process
State your question	Define the problem
Do background research	Do background research
Formulate your hypothesis, identify variables	Specify requirements
Design experiment, establish procedure	Create alternative solutions, choose the best one and develop it
Test your hypothesis by doing an experiment	Build a prototype
Analyze your results and draw conclusions	Test and redesign as necessary
Communicate results	Communicate results

Form to Submit 3 GREAT Ideas for Teacher to review

#1 <u>Science Fair Ideas</u>

Question Strategy for final idea

- How can I change something to affect the action? (manipulate)
- How can I measure or describe the change to this action? (quantify)
- What materials are available for conducting experiments?
- Can I do multiple trials?

STEM Loan Library has lots of equipment that you may borrow to do your experiment!

For Experimental Projects

Write a Hypothesis & determine the Independent & Dependent variables (and the CONTROL):

- A Hypothesis is an idea about the solution to a problem, based on knowledge and research; it can be tested by observations or experiments, about the natural world.
- In order to be considered scientific, hypotheses are subject to scientific evaluation and must be falsifiable, which means that they are worded in such a way that they can be supported or rejected.
- All of your project experimenting will be performed to test the hypothesis.

GUIDELINES:

- written in 3rd person (no "I think"), written in PRESENT TENSE
- CLEARLY States what is to be accepted or rejected
- written as a statement --- CANNOT Be A QUESTION.

Checklist for Hypothesis or Engineering Design

Explanation of Independent & Dependent

- The **independent variables** are the **manipulated variables** (what you change to test against the control).
  - **Control is part of the independent variables.** Every good experiment has a control. **A control is used to measure the manipulated data against. It is a test in which the independent variable is kept constant in order to measure changes in the dependent variable.** A control is a neutral "reference point" for comparison that allows you to see what changing a variable does by comparing it to "not changing anything".
- The **dependent variable** is what "varies" as result of the manipulation of the independent variable (**what is being MEASURED; in metric if applicable).**
- Factors that are identical in both the experimental setup and the control setup are called the **constants** (these are kept the same for all variables).

Examples

Topic: Is green bean seed germination affected by acidic or basic growing environments?

Null Hypothesis: Soil acidity does not affect seed germination.
Alternate Hypothesis: More neutral pH levels of soil will produce a higher germination rate.
Independent variables: different pH levels from acidic to basic. Acidic: pH 4; pH 5; Neutral: pH 7; Alkaline/Basic: pH 8; pH 9. **Control**: pH 6 because that is the common pH level for soil in LA.
Dependent variables: Green bean seed germination rate calculated by total sprouted/total tested x 100 and Time in hours/days for the most seeds to germinate.
Basic idea: Wet the paper towels with different solutions. Using pH strips or a pH meter, make the different pH levels listed in above in the Independent Variables. Use distilled water and add diluted vinegar to make the acidic pH levels. Use baking soda added to distilled water for basic/alkaline conditions, and plain distilled water for neutral.

Objective: To determine if the UV index of the top rated iPhone apps for UV monitoring will produce the same results.

Hypotheses:

Null: There will be no difference between the UV index readings of "free" and cost phone apps.
Alternate: More expensive UV index phone apps will produce different UV index readings than the "free" version apps.
Independent variables:
4 different highly*rated UV personal index apps and a handheld UV index meter
*https://www.appicker.com/applists/24061/the-best-iphone-apps-for-uv-monitoring-2021
8 readings taken every 30 minutes from 11 a.m. - 2:30 p.m. for 10 sunny to partly cloudy days.
Control: UV Index meter
Dependent variable: calculated/experimental mean for each app calculated over the ten-day period.
Procedure: I will download 3 apps on my cell phone and borrow a UV index meter to use as the control. I will conduct 10 readings every 30 minutes from 11 a.m. - 1:30 p.m. using all 3 devices in the sun (I will wear sunscreen and sunglasses for protection). Averages will be calculated and compared. This is how I will measure: Difference from the Control/Accepted value calculated by: |accepted value - experimental value| \ accepted value x 100% Percent error is the difference between a measured or experiment value and an accepted or known value, divided by the known value, multiplied by 100%.
https://www.thoughtco.com/how-to-calculate-percent-error-609584

For Engineering Design Projects *(instead of a hypothesis)*

Define a Need: What do users of your product need? Is it a new version of an existing product that has more speed, lighter weight, or lower cost? Or, is it a product with an entirely new combination of features never before seen.

Who is your target user or customer? who will use your product.

Do Background Research: What is currently on the market? Investigate what others have already learned about your idea. Gather information that will help you design your invention. Don't reinvent the wheel.

What will be your design criteria? **Establish Design Criteria**: Design criteria are requirements you specify for your design that will be used to make decisions about how to build the resulting product. For example, you might set out to design a baseball bat that has design criteria calling for the same strength and size as an aluminum bat, but half the weight. These criteria would rule out making the bat from balsa wood (not strong enough) or steel (too heavy). They would lead you to look at materials like carbon fiber composites (very cool stuff, but expensive).

Engineering Design Example

Define a Need: My mom's potted plants are being eaten (they eat the roots and bulbs) by squirrels on our porch. My idea is for a porch garden protection system that will not harm animals but scare them away.

Define your target user or customer: My target group is aimed at amateur gardeners who want to protect their vegetables from squirrels and birds who are eating them.

What is currently on the market?: solar electric fencing; bird netting; sprinkle hot pepper on them, or Tabasco sauce or cayenne pepper; hang a plastic owl on a plant hook near the tomatoes; and cage your tomatoes. Also Training the squirrel terminator: https://hackaday.com/2018/04/30/training-the-squirrel-terminator/

What will be your design criteria(s)?

- Cost to purchase or use: I want to keep my prototype/product cost under $75.00 and then have the plans available for others to build and to sell the finished product for under $75.00..
- Lifespan/Protection from outside elements such as rain and wind: I want my product to have a covering to keep the electronic parts from getting wet and stop working.
- Size: I am trying to determine what my size constraints will be but ideally, I want my product to work for a small sized garden or several plants.
- Harming the animals: I do not want the animals to be harmed in any way but just frightened enough to not return and eat the plants.

How will you build a prototype & test?

I am going to use an arduino and have a motion sensor and it will release a sound that will scare squirrels away but not harm them.

Form you can use for the final hypothesis or engineering design approval

#2 Science Fair Hypothesis or Engineering Design

Your hypothesis or engineering design idea has been approved….. What comes next?

Developing a Research Plan

- Develop a PLAN/ guideline for your hypothesis/ engineering design idea.
- Research the scientific concepts involved to help you understand.
- Look at similar experiments/ ideas and LEARN from their experiences. <u>Scientific literature review in extremely important</u>.
- Develop procedure to test your hypothesis or meet your engineering design criteria.
- Determine how to analyze the results.

Research Plan TEMPLATE

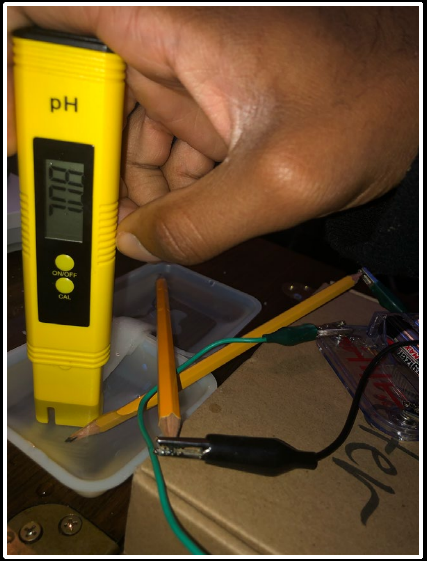
https://tulane.app.box.com/s/4bqtdiyb1z5t81b0j18g8glu6d5pgf17

FYI- example of procedure with a photo

Methodology example

Magnesium sulfate was used as the “salt”. 200 mL H2O + 45 g of magnesium sulfate were dissolved and evenly poured into two plastic containers. A paper towel square was placed into both solutions to form the “salt bridge” between them. Graphite pencils (each side sharpened) were placed into the solutions and the wires were attached to the battery terminal with alligator clips. A pH meter was used to record the pH values initially (control), at 10 minutes and then at 25 minutes for 6 trials.

(safety goggles and nitrile gloves were used to protect eyes and hands).



Example Research Plans

- Animal Research Plan
- Biochemistry Research Plan
- Biochemistry Research Plan2
- Engineering Design Research Plan
- Engineering Design Research Plan 2

Doing the experiment

Remember to add reliability, multiple trials are needed.

Results: Data Table, graph & Conclusions Checklist

https://docs.google.com/document/d/1I9x0Rguv8lDLYxvEOaYcgS8flsL0jArdHxwrii3lZHk/edit

Examples are given on the following slides

Results: Data Table, Graph & Conclusions (experimental projects)

Data Table: must show *at least* **6+ trials AND an average**. Generally, the Independent Variables go DOWN/vertical the chart and the trials and average go across/horizontal. This must be typed and have the units labeled in the title. (For example: % of Stain Removed). Must also include MEAN (average) and Standard Deviation. https://www.mathsisfun.com/data/standard-deviation-calculator.html
(choose "sample" rather than population). Enter in each trial value and then put a comma after the value.

% of Stain Removed

Type of Cleaner	#1	#2	#3	#4	#5	#6	Mean	SD
Brand G Generic	75	50	75	50	75	50	62.5	13.7
Brand E Expensive	50	50	25	50	50	50	45.8	10.2

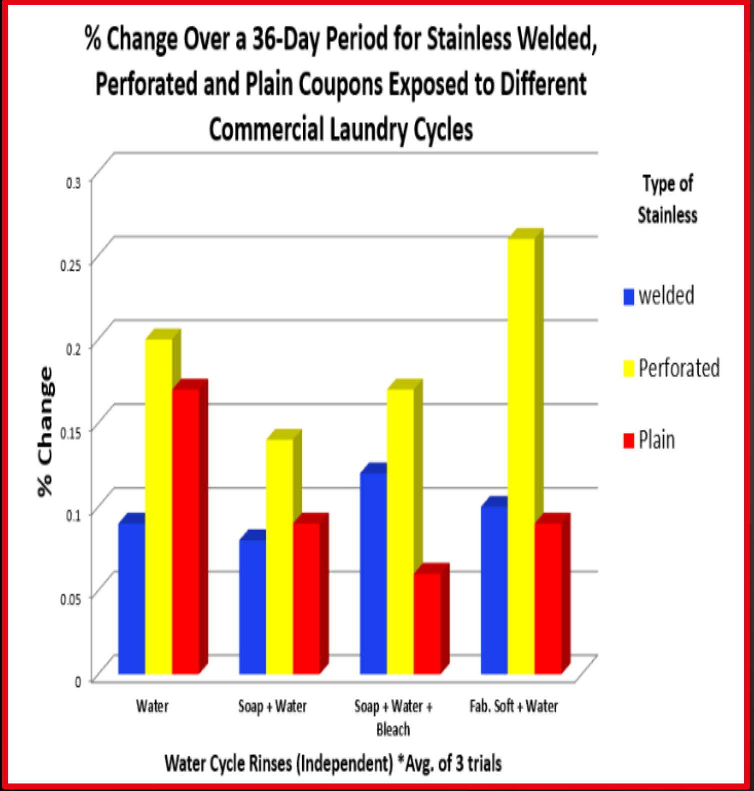
Does Voltage Affect pH Levels Between Salt Bridges?

Oxidation/Reduction Reaction Initiated by an External Voltage Source (3-V)

Voltage Source	Initial pH level (control)	pH level after 10 min.	Difference from initial <pH>	pH level after 25 min.	Difference from initial <pH>
3-V (New batteries for each trial)			<decrease>		<decrease>
Trial #1	7.34	7.09	0.25	6.90	0.44
Trial #2	7.34	7.10	0.24	6.93	0.41
Trial #3	7.34	7.08	0.26	6.94	0.40
Trial #4	7.34	7.08	0.26	6.94	0.40
Trial #5	7.34	7.06	0.28	6.93	0.41
Trial #6	7.34	7.07	0.27	6.92	0.42
Mean		**7.08**	**0.26**	**6.93**	**0.41**
Std. Deviation		0.014		0.015	

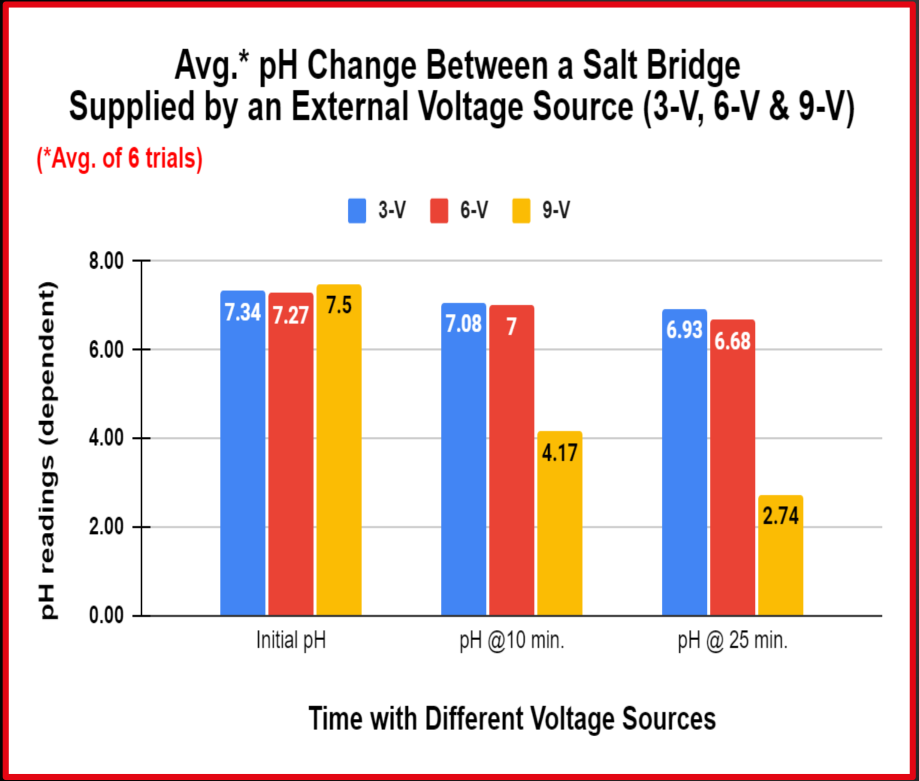
Another example: Data Table

Results, Data Table, Graph & Conclusions (experimental projects)



<u>Graph:</u> Graph must be of the **<u>AVERAGE</u>.** **Do NOT GRAPH each trial.** *Graph the **<u>average</u>*** and clearly indicate at the *bottom, right-hand corner, how many trials it is the average of.* The independent variables are on the X-axis and the dependent variable (what you are measuring) is on the Y-axis. You must measure in metric if applicable!

Another example: Graph (experimental projects)



Graph: Graph must be of the AVERAGE. **Do NOT GRAPH each trial.** *Graph the* ***average*** and clearly indicate at the *bottom, right-hand corner, how many trials it is the average of.* The independent variables are on the X-axis and the dependent variable (what you are measuring) is on the Y-axis. You must measure in metric if applicable!

Results: Data Table, Graph & Conclusions (experimental projects)

Take photos of entire process and especially the results. This is an example and continues onto next slide.

Conclusion:

The data I collected rejects my null hypothesis because instead of there being no mass or visual changes, all four solutions increased the mass and caused minor visible changes in the coupons. This experiment tested the effects of varying solutions on the stainless steel tubs in the commercial laundry industry. This was accomplished by agitating each solution for 3 minutes everyday over a period of 5 weeks. The four cycles used were Cycle 1: Water, Cycle 2: 10% Soap + water, Cycle 3: 10% Hypochlorite + 10% soap + water, Cycle 4: 10% Fabric softener + water. Each solution had three plain, perforated, and welded coupons/samples secured inside. Cont. onto next slide

Cont. from previous slide

The assumption made at the beginning of the experiment was that Cycle 3 would cause the greatest amount of mass loss. The resulting effects on the stainless steel proved that assumption incorrect. This is because instead of just one cycle causing a mass decrease, all four cycles caused a mass increase for every sample used (excluding the control). The perforated samples exposed to Cycle 4 showed the greatest degree of change at 26%. The lowest degree of change, belonging to the plain samples exposed to Cycle 3, was 6%. There were few physical changes observed. Many of the samples were simply dulled, and some (specifically those soaked in cycles 3 and 4) had the labeling washed off by the solutions. The welded coupons that were in Cycle 1 were corroded (dull to dark gray) around the welded area. Cycles 2 and 4 seemed to have left a residue over the coupons.

<u>Potential Sources of error</u>: I found the results surprising because I did not expect the samples to gain mass. Reasons for this may include:

1. scale may have not been calibrated correctly or it may have been a different scale (I just one of the scales in the school lab).
2. Was there any residue on the scale's surface to cause it to read faulty? Did air conditioning or no air conditioning possibly affect the accuracy of the scale?

Next time:

<u>In the future</u>, I plan to increase the testing time to see if this would change the mass gains that I found in this year's experiment. I would also use more coupons in each test group to increase the reliability of my findings and place the coupons in separate containers (no contact with each other). Based on my literature review, aeration is important in simulating a corrosion environment, therefore, I would agitate/swirl the solutions daily to add oxygen to the containers.

Another Example

Conclusions

<u>Conclusion:</u>

The data rejects the null hypothesis that a 9-V battery (electrochemical cell) would not have an effect on the pH level of the magnesium sulfate solution using a single salt bridge. The salt bridge completed the pathway between the two solutions. After 6 trials, the 9-V volt battery decreased the pH level of the solution (from neutral to very acidic) with a paper salt bridge, from the initial pH of 7.5 to pH 4.2 after 10 minutes, and then to an average pH of 2.7 after 25 minutes. pH expresses the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid and higher values more alkaline. The higher potential difference (voltage) applied allowed the cathode to have more energy to bring about reduction, and the anode to have more energy to initiate oxidation and thus lower the pH level (more H+).

There was very little change in the pH values for the 3-V and 6-V battery for the 25-minute time period. This indicates that the potential difference was not enough to allow the electrolysis cells to begin passing electrons and cause the oxidation/reduction reaction in the solution. Since current is the driving force in electrolysis, the amount of charge (flow of electrons using the 3-V and 6-V) was not enough to change the pH. An oxidation-reduction reaction is any chemical reaction in which the oxidation number of a molecule, atom, or ion changes by gaining or losing an electron. Next time, I would try using different salt solutions and metals as the electrodes to better understand the electrochemical process.

Next slide is an EXPERIMENTAL Project Poster to help you understand results and conclusions

How Does pH Level Affect the Digestion of Protein?

What is the ideal pH level for the stomach enzyme, pepsin, to digest proteins?

Hypotheses & Variables

Null:
The pH level will not affect the digestion of protein.
Alternate:
Lower pH levels will increase protein digestion.

Independent:
pH level: 3; 4; 5; 6; 7; (control: pH 3 because it is the normal pH of stomach acid)
Dependent:
% of Egg White Dissolved

Methods

Different pH levels were tested to determine their effect, combined with pepsin, on the digestion of protein. Hard boiled egg white pieces were added to each test tube along with the enzyme pepsin, and incubated at 37 C for 30 minutes. The digestion (dependent) was recorded based on % of egg white that dissolved.

Percent* of Protein (Albumin) Dissolved After Adding Pepsin With Different pH levels

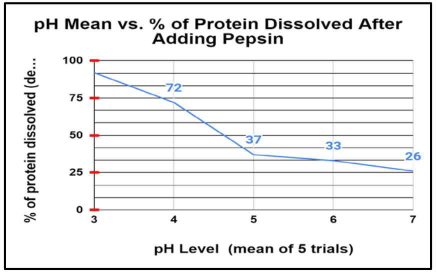
pH Level	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Std
7	25	25	35	25	20	26.0	5.5
6	35	30	40	30	30	33.0	4.5
5	35	35	40	35	40	37.0	2.7
4	80	70	75	60	75	72.0	7.6
3	90	95	90	90	95	92.0	2.7

*Visual estimation of amount of egg white remaining after 30 minute incubation at 37 C

Results

The lower pH levels (more acidic) dissolved a much higher % of the egg white (protein, albumin) than the higher pH levels (more basic).

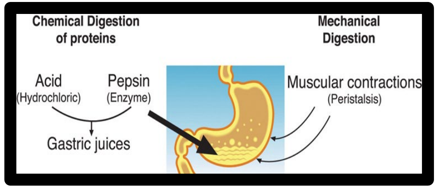
- **pH 3 dissolved 92% of the egg white (protein)**
- **pH 4 dissolved 72% compared to the neutral pH of 7 with 26% in the 30 minutes with the enzyme pepsin.**



Conclusions

The results rejected the null hypothesis that "The pH level will not affect the digestion of protein". Pepsin, when activated by lower pH levels dissolved albumin (egg white protein) faster than more basic pH levels.
These results support what I learned in my literature review.

- **Proteins are digested in the body by a stomach enzyme called pepsin.**
- **Gastric chief cells secrete pepsin.**



https://med.libretexts.org/Courses/American_Public_University/APUS%3A_An_Introduction_to_Nutrition_

The stomach releases gastric juices containing hydrochloric acid and pepsin. Proteins are digested by pepsin which responds to lower pH levels

photos, data table & graph by student

ENGINEERING DESIGN

Next slide is an Poster and will give you an idea of a good example of results and conclusions for an engineering design project

Squirrel Squealer: No Harm - only Scaring Squirrels Away from Your Potted Plants!

Sawyer Barron

Engineering Objective

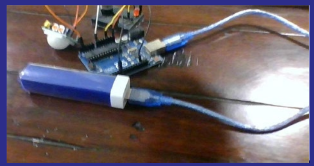
Safely deter squirrels from eating the young roots of my mom's potted plants.

Engineering Goals

- **Scare squirrels away from potted plants on a porch but cause them no harm.**
- **Size will be small but effective for a small to medium sized porch area.**
- **Use a small power bank which would last approximately 30 hours of active use.**
- **Protection from outside elements such as rain, wind, and children (plexiglass covering).**
- **Easy to set-up and use.**
- **Keep prototype/product cost under $75.00; have the plans available for others to build; and to eventually sell the finished product.**

Methodology

- **I researched similar products used to scare animals away from plants and came up with several ideas.**
- **I sketched designs and then watched YouTube tutorials on how to code and build the Arduino.**
- From my drawing, I built the device (jumper cables, breadboard, infrared PIR motion sensor, Arduino, buzzer) and added an LED to alert me when the device would go off. This helped me know when the 20,000 Hz sound went off, since I could not hear it (I could hear the other frequencies).



Testing

I connected the Squirrel Squealer to a power bank on my porch near the potted plants they like to eat, and then hid 3 meters away. I waited for squirrels to pass by and I tested sound levels of 3,000 - 20,000 HZ frequencies and found 5,000 HZ to be the optimal level to quickly alert and cause the squirrels to run away. *(some humans can hear up to 20,000 HZ; above that could scare birds*).*
Tests were done in the morning and evening for 30 minutes.

***squirrel image:** https://escholarship.org/uc/item/1kp2r437

Number of Squirrels That "Ran" From Plants with the Squirrel Squealer

Time	Test #1 Observed/ Ran Away	Test #2 Observed/ Ran Away	Test #3 Observed/ Ran Away
8:30 - 9 a.m.	4 / 4	3 / 3	4 / 3
4:30 - 5 p.m.	8 / 6	5 / 5	9 / 8

Conclusions

The cost of the Squirrel Squealer was $63.00 but that does not include a covering/case to protect it from the weather. The "sound" (20,000 HZ) to scare the squirrels was activated with the Motion Sensor and this worked well (above 20,000 HZ could scare birds).
The current size is 20 cm (wide) x 25 cm (length) and a height of 13 cm. This would work for a porch area.

- **Future Plans:**
  - **Camera for further testing**
  - **Test distance & motion range of sensors**
  - **Reduce size**
  - **Add plexiglass covering**

Squirrel images from Google clip art; photos & data table by student

Information/ Images

https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-compare-scientific-method

Information & forms used by former science teacher and everyone is welcome to DOWNLOAD, edit and use as needed

Clip art from Google images

Please feel free to DOWNLOAD & modify any of the forms or checklists in this presentation