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Engineering Fair Curriculum

What's an Engineering Project?

In a traditional science fair experiment you test a hypothesis through experimentation. In an engineering project you **design** a new solution to a problem, **build it**, and **test the outcome**s. You might do this process several times in order to create the best outcome. Since you are coming up with the design, you won't be using a kit.

The benefits of participating in the engineering process:

- Create solutions to real world problems which interest you.
- Choose how you want to work, alone or in a group of 2 - 3.
- Solve a personal issue or help others solve a problem.
- Apply what you have been learning or know.
- Win cash awards, scholarships, and other prizes.
- Travel to other competitions at the Regional, National, & International level.
- Prepare yourself for college with independent work.
- Meet engineers who are experts in your areas of interests.

What's the Engineering Process?

The engineering process is the guide to help with the creation of a new product, or innovation. You take your idea through the series of steps which helps you decide if your idea is unique by seeing what others have done to try to solve the problem (research); helps you decide what you want your innovation to accomplish (design criteria); helps you take your idea and create plans to build your innovation (preliminary design); helps you build and see how well you solved the problem (building and prototype testing); helps you change your prototype to make it better (redesign and retest); and helps you share what you have discovered (conclusion).

Step 1: Identify a Topic and Decide if a Team is Needed

Before forming an engineering team, discuss 1) individuals' availability and schedule for being able to get together; 2) what talent they can bring to the project; and 3) agree before you start what to do when a member can not meet or does not do an assignment. Just because you are friends does not mean you should become team mates.

Step 2: Get Approval and Permission

ISEF Rules Wizard can help you determine if additional forms and permissions are needed. For instance, if your project uses physically hazardous material (i.e., bacteria), human, or animal subjects you need approval before you start experimenting. If your project is a continuation from last year, performed in a facility outside school or home, or needs scientist's supervision then you need permission and additional forms. See ISEF Rules Wizard (http://apps.societyforscience.org/isef/students/wizard/) for forms.

Even if your project is not using the materials or subjects previously mentioned, you **must** fill out ISEF forms before you begin experimentation. If you are experimenting at home or at another site prior to filling out the required forms, then you are not participating in the engineering process.

Always work under the supervision of several adults to avoid accidents in the prototyping and testing processes. Discuss with mentors the hazards which could result throughout prototyping and testing; take all necessary precautions to avoid such outcomes.

Give a **copy** of any forms to your teacher and keep originals safe. After you have finished your project, complete an ISEF Abstract (available at drsef.org). Give a copy to your teacher to go with the copies of the other ISEF forms and display a de-personalized copy (cover name/school) with your project whenever you exhibit. For a **team project**, only one registration is needed for the whole team.

Step 3: Understand Teacher/ School/ District Fair Due Dates

Find out the date your engineering project is due. Make a timeline for when the different components of the process are due.

Step 4: Use the Engineering Fair Template

Using the following template with headings, indented subheadings, and bullet points will help you include all the components of the engineering process. Following each heading, an example is shown to help complete your text.

Engineering Fair Template

Need Defined *(Use this heading)*

Engineering Problem: *(Use this indented sub-heading)*

- Address the current issue(s) to be solved through the engineering process.
- Are there problems with current technology, problems involving the user, or problems affecting the environment?
- List possible consequences of leaving the problem unsolved.

Example of Engineering Problem: "Plastic louvers on dryer vents often get stuck open and permit mice to crawl into the dryer exhaust tube. The rodent (1) could die causing odor and unsanitary conditions or (2) gains access to the residence with the possibility of spreading disease."

Engineering Objective: *(Use this indented sub-heading)*

- Describe the intended goal of this innovation; what problem(s) will be minimized/solved?
- Begin objective with verbiage, "To design and manufacture..."

Example of Engineering Objective: "To design and manufacture a passive (automatic) device preventing rodents from accessing the dryer exhaust through the outside vent while minimizing energy loss between the home and outdoors."

Research *(Use this heading)*

In order to create a design to solve the problem, extensive research must be done in order to avoid recreating an existing process or known technology.

- Start the research process by building off current knowledge or past experience.

  Example: "During the cold winter months, after the dryer has finished its cycle, rodents can feel the warm air, and they can often access a home through the louvered exhaust vent's flaps."
- Research existing innovations or processes. How could these existing technologies be improved? Consider the following problems: the cost of manufacturing, energy efficiency, operational safety, etc.

- If there are no current innovations or processes to address this problem, make sure to note this idea/innovation is unprecedented.

Abbreviated Example: "Currently there are three basic designs of dryer exhaust vents…the Louvered Exhaust Vent allows rodents to access the home and is not energy efficient..."

- Take research information for various websites and utilize different research resources (i.e., university videos, scientific journals, market studies, interviews with industry members, etc.).

- To avoid plagiarism and to give credibility to your research, correctly cite all sources using the APA format.

Example: "The U.S. Consumer Product Safety commission (2009) estimates in 1998, clothes dryers were associated with 15,600 fires." (In text citation)

1- "Dryer Safety." (2009). Orange County Fire Authority. Retrieved on December 20, 2009 from http://www.ocfa.org/_uploads/pdf/dryersafety.pdf

- Throughout the research process, list design considerations (ideas and elements) useful to include in your designs and prototypes. This list will be used to create the project's Design Criteria and during testing will determine if the project's engineering innovation (prototype) meets the original Engineering Objective. Possible elements may include, but is not limited to: safety, aesthetics, cost, efficiency, ease of manufacturing, maintenance, and other considerations specific to the original Engineering Problem.

Example: "First, the design needs to have the lowest possible air flow restriction so humid air can be exhausted and replaced by dry, warm air so clothes dry quickly."

Engineering Hypothesis

- Using your Engineering Objective, create the Engineering Hypothesis in the form of an "If…then" statement. **If** the innovation is designed and manufactured, **then** the problems previously mentioned will be diminished.

Example of Engineering Hypothesis: "If a passive dryer exhaust vent device is designed and manufactured to prevent rodents from entering while minimizing undesirable air flow, then (1) rodents will be unable to enter and die in the exhaust tube and (2) energy loss between a home and out of doors will decrease."

Design Criteria

- From your experience and research, describe the characteristics the prototypes must possess. The Design Criteria may consider, but is not limited to: safety, visual appeal, economic feasibility, efficiency, ease of manufacturing, maintenance, and the original problem. Consider the ideas and elements you listed in the Research section.
- Each design consideration in the Design Criteria should have a bulleted sentence and then go into specifics concerning the characteristics of this design consideration.

Example of Design Criteria: "Design needs to allow the dryer to operate safely. The device can't lead to a house fire."

  - To safely operate dryer, design cannot have lint traps including screens or cages."

Engineering Solution Table Design Phase

- Create at least five designs and sketches pertinent to the Engineering Problem and Objective. **Do not create a prototype during the Design Phase.**

- Compare these sketches to the established Design Criteria.

- Some of the brainstormed designs may not pass all components of the established Design Criteria. The design that best meets the established Design Criteria is the best candidate for initial prototyping and/or you may make an additional design and sketch based on the best features of the previous designs; just recheck the new design against the Design Criteria.

Example of Checking Designs against Estabilished Criteria:

Lowest Possible Air Flow Restrictions	Dryer Operates Safely	Energy Efficient/Reduces Convection	Reduce Conduction / Easily Manufactured	Maintenance Free	Economically Feasible (Mass Production)	Prevent Rodent Access
X	X		/ X	X	X	X

Materials

- Following the Design Phase, take the most successful design and begin listing the materials need to create the first prototype.

- Throughout the prototype, test, and redesign phase list all the materials, tools, and equipment used. List the dimensions, volume, or mass of the materials used; all units must be converted to the metric system.

- When listing equipment include the model number and company name.

  <u>Example of Materials</u>: "1 shoe box (27.94 cm x 19.05 cm x 10.16 cm), 1 EXTECH 401021 Foot Candle Light Multimeter Adapter, and 8 Kirkland garbage sacks; 170.34 liters (1.2 mm thick)."

<u>Procedure</u>

- Consider when (time of day) and where the equipment used in testing and prototype will work most efficiently. Document the test location/ environment and procedure for testing prototype.

- By maintaining a controlled testing environment, testing may be replicated multiple times (at least three) and maintain similar results.
  - Identify all the controls for testing.
    - The controls (i.e., temperature of the testing environment, time of day tested, etc.) are the components that do not change throughout experimentation.
    - **<u>Example of Controls for Testing</u>:** "Considered dark basement with a drop-down fixture for test light but noted the temperature was eight degrees cooler than main floor. The research indicated compact fluorescents would not work as well in cool environment."
  - Identify the variable for testing.
    - To viably test the prototype, there must be at least one variable control (i.e., temperature, distance something is moved, light intensity, etc.) which changes and can be measured and collected during the testing of the prototype.

  - The variable measurement will allow the results from each designed prototype to be compared to your established Design Criteria to determine if prototype meets Engineering Objective.

- Document the method for making each prototype.

- **Example of Documenting Prototype:** Evaluated Design #8 and determined another fixture was needed to be designed, prototyped, and tested to decrease the range between the lowest and highest data point and provide a more consistent distribution of light."

Analysis

Each prototype created and tested must have a "Results and Analysis" section and must contain the following:

- Engineering Hypothesis; students' prediction of how prototype is assumed to act, this was formulated during the Design Phase.

- Actual results of the test (each prototype must be tested three times to demonstrate reliability of testing) and recorded in metric units.

- Description of the prototype tested, i.e., what made it different from past prototypes.

- Conditions of the testing environment.

- Date tested.

- Evaluate the actual results against established Design Criteria.

- Graph(s)-specific to variable(s) and testing environment.

- Problems with prototype.

- Successes with prototype.

- Sketch of prototype; include measurements (reported in metric).

- Summative statement making "Recommendations for Future Designs."

  Example of Recommendations: "Recommendations for Future Designs: Approach power utility company asking for mini-grant to purchase LED street bulbs for Riverton City. Prototype a weather resistant 50, 60, 70 fixture and test on city light poles."

Conclusion

- Engineering Problem
  - **Example of Addressing Problem:** "Street light fixtures are designed to direct light for different purposes. Too often, these fixtures direct light into the sky where it is not needed...

- How Problem was addressed.

- Brief description how procedure was conducted.

- Results from all prototype tests; were there any surprising results?
    - **<u>Example of Results of Testing</u>:** "All design fixtures prevented light trespass. However, the final prototype, "50, 60, 70 Fixture," provided a consistent distribution of light over the intended area using both compact fluorescent and LED technology..."

- Possible errors, human or equipment.

- Description of possible project continuation.

- If the best prototype was manufactured for public use, how would the prototype affect society or the environment?

Real World Connection

- Describe how the idea for this innovation occurred; was there a specific need or event that required such an innovation?

- Describe if the best prototype was manufactured for public use, how would the prototype effect society or the environment?

  <u>Example of Real World Connection</u>: "I was at the University of Utah where a physics graduate student discussed the effects of light trespass at their observatory...If fixtures were replaced with Design #9, which directs light to the intended area, then light trespass would decrease leading to better air quality as less energy would be needed to produce energy..."