Engineering & Technology Program Supplement

ENGINEERING AND TECHNOLOGY PROGRAM SUPPLEMENT

Table of Contents

I. Introduction

II. Welcome to Engineering and Technology Exploring!

The influence of technology in our daily lives is increasing rapidly, and interest in engineering and technology careers among young adults in the United States remains high. To encourage and support this interest, the Exploring Program has developed this program guide to assist in planning and conducting programs for engineering and technology Explorer posts.
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Engineering and Technology Exploring

In 1979 the National Society of Professional Engineers NSPE agreed to endorse Engineering & Technology Exploring and to provide support for the formation of posts and related activities. The Engineering & Technology Advisory Committee was formed in 1994. It is made up of practicing engineers throughout the nation. Their goal is to promote engineering careers to today's youth through Exploring.

What Is Engineering?

Engineering is problem solving. Engineers use the forces and materials that occur in nature and mold them into something useful to people. "Engineering" dates from the beginnings of humankind. The "discovery" of fire and how to use it, the fashioning of the first primitive wheel, and early irrigation for cultivation of crops were all engineering feats. Engineers make things work better, more efficiently, quicker, and less expensively, and they create products and services that serve people's needs.
The scientist explores what is. The engineer creates what has not been. The scientist examines the forces and materials in nature so that they may be accurately described and understood. The engineer uses that knowledge and understanding to create useful products.

What Is Technology?

Technology is defined in the dictionary as the science of the practical or industrial arts, or as applied science. It involves the application of proven technical processes, techniques, devices, and materials in solving problems and in developing new systems and products to meet human needs. It requires the use of existing scientific and engineering knowledge and methods, and special skill in their practical application to the problem at hand.

III. Engineering and Technology Careers

The Engineering Profession

Engineering- and technology-related industries compose the largest segment of the U.S. economy. In 1996, there were approximately two million engineers in the work force. It is a "learned" profession in that it requires formal education in its preparation and advocates lifelong learning for its practitioners. Engineers also subscribe to codes of professional conduct and codes of ethics. The preamble and fundamental canons of the NSPE Code of Ethics and Engineer's Creed are shown in appendix 1.

Specialties

The profession is organized into a number of specialties or "disciplines." Most engineers are engaged in one of the six major specialties: **chemical, civil, electrical/electronic (includes computers), mechanical, industrial, aero/astro**. Other specialties include **automotive, agricultural, architectural, biomedical/-mechanical/-chemical, environmental, nuclear, petroleum, heating/ventilating/air conditioning, fire protection, naval, ocean**, and many more. Most engineering challenges involve several engineering disciplines, so engineers typically work in teams.

Engineers, Technologists, and Technicians—The Engineering Team

Engineers not only work with other engineers on projects, they also work with technologists and technicians. This is often referred to as the "engineering team." The team can be expanded to include scientists, architects, financial experts, and others as the project demands.
The **engineer** has a strong science, mathematics and technology background gained by study, experience, and practice and applies that knowledge with judgment as a member of the team, often as the team leader. He or she must be able to interrelate engineering principles with economic, social, legal, aesthetic, environmental, and ethical issues, extrapolating beyond purely technical considerations. He or she is a conceptualizer, a designer, a developer, a formulator of new techniques and standards—all to help meet societal needs. Engineers plan, design and supervise engineering projects from conception to completion.

An **engineering technologist** must be applications oriented, building on a background of applied mathematics. Based on applied science and technology, the technologist must be able to produce practical, workable results quickly; install and operate technical systems; and devise hardware from proven concepts. He or she translates the engineer's designs into systems and projects.

The **engineering technician** collects and analyzes data, develops design layouts, checks and repairs equipment, and assists in preparation of reports for the team. He or she is a doer, a builder of components utilizing proven techniques and methods with a minimum of supervision from an engineer or technologist.

College Preparation
Becoming an engineer requires a four-year degree from an accredited **engineering** program. A list of such programs is available through the Accreditation Board for Engineering and Technology (ABET), telephone 410-347-7700. Also, information about accreditation and a list of accredited programs in engineering and in technology and the colleges offering them can be found by accessing the ABET home page on the Internet at http://www.abet.ba.md.us.

An engineering technologist usually holds a four-year degree from an accredited **engineering technology** program. A list of such programs is also available from ABET. Engineering technicians usually have two years of post-secondary education, preferably in engineering technology with emphasis on technical skills.

Many community colleges have two-year technician programs and four-year technician/technologist programs. Some also have agreements with state engineering schools that allow transfer of the first two years of credit toward an engineering degree.

High School Preparation
Because of the demands of an engineering education, it is important to begin preparation early in high school. Those wishing to enter engineering school should take algebra 1 and 2, trigonometry, biology, physics, three units of social studies, one or two units of fine arts/humanities, geometry, calculus, chemistry, four units of English, two or three units of foreign language, and computer programming or computer applications. Advanced placement or honors courses are recommended. High school guidance counselors can often assist in determining which courses are appropriate.

Financial Aid for College
Scholarships and grants are available from many of the engineering societies in appendix 2. The NSPE state society office of the state of residence also has information on scholarships available through NSPE. Finally, the most comprehensive source of

information about scholarships can be found on the Internet by using a web browser and searching for "scholarships" or "engineering scholarships."

IV. Resources Available to Engineering and Technology Exploring

Engineering Societies

Each of the engineering specialties has an association or society representing its practitioners. A partial list of the national engineering associations and their addresses and phone numbers is in Appendix 2. They are a source of information about their specialties and a potential resource for assisting in establishing posts and developing and conducting post programs. Several of these organizations offer resources of particular value to engineering and technology Exploring.

National Society of Professional Engineers. NSPE is a nationwide society with state affiliates and local chapters in every state and territory. It has been cooperating with the Exploring Division since 1979 to help establish engineering and technology Exploring as a distinct and vital cluster within the Exploring program. Local LFL councils have been provided with lists of NSPE state societies and their addresses and phone numbers. Information can also be provided by NSPE customer service at 703-684-4811 and is available on the NSPE home page on the Internet at http://www.nspe.org. NSPE is responsible for two programs of particular interest to engineering and technology posts as indicated below.

- **National Engineers Week (NEW).** NEW is a joint activity of major engineering societies, educational institutions, government agencies, industries, and engineering firms to increase public awareness and appreciation of engineering and technology by emphasizing the positive contribution made by engineers to the quality of life in the United States. It is observed each February during the week of George Washington's birthday. Posts can make it a part of their annual program in cooperation with local observances in their area. Call the NEW hot line at 703-684-2852 or access the NEW web page on the Internet at http://www.eweek.org.

- **MATHCOUNTS.** MATHCOUNTS is a nationwide mathematics coaching and competition program for seventh- and eighth-graders. Explorers can assist in coaching participants and in conducting local and state competitions. This is an excellent service, social, and citizenship project for an Explorer post. Contact the local NSPE state society or the national MATHCOUNTS office at 703-684-2828 or access the MATHCOUNTS home page on the Internet at http://www.mathcounts.org for information on becoming involved.

Engineering Colleges

Engineering colleges and community colleges that teach technology and engineering science courses have a wealth of resources that can assist posts. These include laboratory and other facilities that can be used in post programs and faculty to serve as post consultants and leaders. Posts should establish links with the engineering colleges in their area and involve them in their programs.

Government Agencies

Agencies of the Army, Navy, and Air Force; National Aeronautics and Space Administration; Department of Transportation; Federal Aviation Administration; and Veterans Administration have missions which heavily involve engineering and technology. They have extensive resources and staff devoted to engineering and technical programs and are excellent sources of adult leadership and program support. The Army Corps of Engineers has districts and field offices in every state which are identified in local telephone directories. NASA support is available through educational service offices at regional NASA centers.

Businesses and Industries
Many local and national industrial and service firms provide manufactured products and/or technical services and have substantial engineering and technological components in their work force. In addition, there are a wide variety of engineering firms in almost every community. These are all good sources for program activity and adult leaders, and are potential post sponsors.

Industry Trade Associations
Most industries have one or more trade associations representing the business and professional interests of the firms in that industry. Those associations can also provide information and assistance to posts.

Software
Engineering and technology post Advisors should be aware that there are a large number of computer software packages available that can enrich post programs. these packages range from those involving the design of entire communities to the design of individual buildings and their attendant mechanical and electrical systems. There is also software used in the design of automobiles, aircraft, and various utilities. The software is relatively inexpensive and easy to use and can provide the basis for interesting programs.

Internet
The Learning for Life National Office has a home page on the Internet at http://www.learning-for-life.org. Some councils and Explorer posts also have established a presence on the Internet and can be located by searching on "engineering Exploring.

V. Activities, Projects, and Competitions

Introduction
The activities, projects, and competitions described in this section are at the heart of a successful post program. Hands-on, exciting programs are what stimulate and hold the interest of post members. Many of the activities, projects, and competitions described can apply to more than one of Exploring's five areas of emphasis: **Career Opportunities, Leadership Experience, Service Learning, Character Education and Life Skills.**

Engineering & Technology Exploring Committee
Learning for Life
P.O. Box 152079
Irving, TX 75015-2079

Explorer Post Activities
Introduction. The type of activities described in this section is perhaps the most important part of an annual post program. They have the potential to let Explorers see and experience engineering and technology in action in a real life setting and to interface with the community around them. To be successful, activities of this type, especially those involving travel, must be carefully planned and supervised. The following suggestions are made to assist the post leadership in activity organization...

Facilities Tours
Facilities tours offer a great learning experience about how things are manufactured, materials are produced or processed, or services are delivered. The following are examples of facilities tours that offer great learning experiences for a post activit

A. Manufacturing Facilities Tour
Touring any type of manufacturing plant can be a great activity. Have the host explain for example:
1. Where the raw materials are obtained and how they arrive at the plant.
2. The steps of the manufacturing processes at that plant.
3. The role engineering plays in the manufacturing process.
4. How production is scheduled.
5. How quality is obtained and assured.
6. Special safety hazards (personal and environmental) of the manufacturing system and how they are met.
7. How the product is packaged for shipping.
8. How the product is sold in the market.

B. Process Facilities
These types of facilities include
1. Water and wastewater treatment plants.
2. Chemical, paint, oil, and gas plants.
3. Agriculture and food processing plants.
4. Electric generation plants.
5. Waste disposal facilities such as trash incinerators, transfer stations, landfills, or materials handlers.

C. Service Facilities
1. On-line maintenance facility
2. Military base heavy equipment facility or airbase airplane maintenance
3. Major shipping and receiving centers for trucks, trains, barges, ships, or airplanes. For example, the post office, air express terminals, automobile transfers from ships, etc.

D. Government Facilities
1. Military installations
2. FAA, NASA, and other aerospace facilities
3. Department of Energy national laboratories and nuclear production, storage, and disposal sites
4. Research and testing laboratories such as those at the National Institute of Science and Technology
5. Scientific observatories
6. Facilities managed by the Corps of Engineers

E. Educational Tours
1. Planetariums, aquariums, or space museums
2. Universities, colleges of engineering, research and testing laboratories
3. Science museums

F. Construction Sites
1. Road construction
2. Port construction
3. Building construction
4. Airport construction
5. Bridge construction
6. Home/commercial/industrial plant construction

Personal and Career Development Activities

The post should hold at least one major personal and career development activity every year. Since one of the purposes of an Explorer post is to carry out activities that lead to good career choices, a special program focused on career choices is an essential programming element.

College Opportunities Panel

Invite the dean of engineering or a faculty member from a nearby college of engineering. Have the speaker address the following questions for the attendees.

I. What do we do to get started on selecting a college or university?

II. What high school courses are required to enter engineering?

III. Grade requirements—What are admission requirements both for the college or university and for the school of engineering?

IV. Scholarships

  A. What types of scholarships are available and how do I apply?

    1. Academic
    2. Athletic (College requirements must be met as well as NCAA etc
    3. Performance (drama, band, art, etc.)
    4. Special criteria—Many scholarships are established to help students who fit particular "profiles"—ethnic heritage, parents' employment, field of study, etc. Your counselor and parents can help you find out if you qualify for any such scholarships.

  B. What criteria are used in selecting scholarship recipients?

V. What standardized tests are needed for admission ACT, SAT, PSAT etc

VII. What are the application deadlines?

VIII. Other considerations and questions

  A. Should I consider a community college? Engineering training should start during the freshman year. Students who attend a community college may have to extend the earning of the undergraduate degree to five years instead of the typical four.

  B. Do you have co-op programs? Some liberal arts colleges offer students an opportunity to attend their colleges for two years, where students study the humanities, math, and science. Students then transfer to a university that has an engineering program. At the end of the five years, they are awarded two degrees—a B.A. or B.S. and an undergraduate degree in an engineering discipline.

  Some co-op programs allow students to work one semester and then return to the campus the following semester. Before joining such a program, seek the advice of your counselors, parents, and engineering professionals.

  C. Discuss general vs. specific engineering degrees. You must decide whether it is better for you to pursue a general degree (such as chemical engineering) or a specific one (such as biomedical engineering). Be a good consumer and check this issue out. You will ultimately use your college education in the world of work, and you will want to begin with the confidence that your training has been just what you wanted.

  D. What is the importance of accreditation? Certain majors must be accredited:

    1. Architecture—National Architecture Accreditation Board (NAAB)
    2. Pharmacy—American Association of Colleges of Pharmacy (AACP)
    3. Engineering—Accreditation Board for Engineering and Technology (ABET)

College Student Panel

Invite a student or students (preferably one or more former post members) from your local college or university to discuss their experiences in engineering education. If you have more than one engineering program in your area, invite one student from each campus.

Career Speakers

During the year you might invite local engineering professionals to explore engineering careers. Invite a range of speakers from entry-level engineers to presidents and CEOs who are engineers. Each will give you a different perspective on engineering career development.

Science Olympiad

Activity Description. The Science Olympiad is an international nonprofit organization devoted to improving the quality of science education, increasing student interest in science, and providing recognition for outstanding achievement in science education. The Science Olympiad sponsors tournaments across the country. These tournaments are academic interscholastic competitions that consist of a series of approximately 23 individual and team events, which students prepare for during the year. The competitions follow the format of popular board games, TV shows, and athletic games. Although some events require an individual from one team to compete against other individuals from other teams, most events require teamwork, group planning, and cooperation.

Some events that may be of interest to an engineering Explorer post are:

- **Aerodynamics Aloft.** Design and build a device with greatest time aloft as a factor in the scoring formula.
- **Balloon Race.** Attach weights to helium filled balloons and "race" them to the ceiling.
- **Bridge Building.** Design and build the lightest bridge to carry a standard load, given certain parameters of length, width, height, and materials
- **Circuit Lab.** Given electrical data in a circuit, predict current, voltage, and power consumption.
- **Egg Drop.** Design and build a container to safely protect an egg dropped from a high location
- **Hot House.** As a team, construct an insulated house-like structure to house and retain heat.
- **Mousetrap Vehicles.** Construct a vehicle that uses a standard one-spring mousetrap as its sole means of propulsion
- **Sounds of Music**. Build a musical instrument, describe the principles behind the design, and perform musical selections.

More information about the Science Olympiad program may be obtained from Science Olympiad, 5955 Little Pine Road, Rochester, MI 48064; 313-651-4013.

Requirements

Human resources: Two to four Advisors (possibly one Advisor per event).

Local Council Events

Posts can assist districts and local councils with events such as camporees, klondike derbies, and model car races. Posts can also participate in popcorn sales, food drives, and other council events. Opportunities where engineering skills can be used to solve real-world problems are especially worthwhile. Ask the Exploring director for ideas.

An important part of the Engineering post program is the outdoors. While many engineering Explorers tend to focus on technology, don't underestimate the fun they can have in more traditional outdoor programs such as canoeing, rappelling, and backpacking.

Engineering Superactivity

The highlight of your engineering post's annual program should be its superactivity. A superactivity is a major project, trip, or other event that piques the interest of your post's members and serves as a long-range goal around which to rally your post's program. A superactivity requires long-range planning and extensive preparation. The first step is selecting a superactivity that all post members want to do and commit to it. The money, equipment, leadership, and transportation seem less challenging once the commitment is made. The details of planning, example budgets, and necessary travel paperwork to be completed for the superactivity are explained thoroughly in the Explorer Leader Guide.

Examples of Superactivities are:
- Test facilities or bases of the Army, Navy, Marine Corps, Air Force, Coast Guard, Merchant Marine, or National Guard.
- Corps of Engineers facilities such as dams, flood management projects, and harbor dredging projects in coastal areas.
- Major technology or science museums such as the Smithsonian Institution or the Smithsonian's National Air and Space Museum in Washington, D.C.
- NASA space facilities at Kennedy, Johnson, Goddard, Vandenberg, or White Sands.
- Congress and the Capitol of the United States in Washington, D.C., or state capitols with tours guided by state capitol engineers.

Exploring ancient Indian cliff dwellings at Bandelier National Monument combines outdoor experience with a broader understanding of our diverse national heritage
- Monuments and/or national parks such as Grand Teton, Great Smoky Mountains, Rocky Mountain, Shenandoah, Yellowstone, Yosemite, and Zion national parks; Mount Rushmore National Memorial; and Gateway Arch in St. Louis.

Engineering/Science Projects
Introduction. Many of the projects described in this section can be worked on individually or in teams. Wherever possible, teamwork should be encouraged. Many can be completed at a single post meeting, though some require longer periods to complete. Many of these projects are also suited to individual or team competition. (See also the section of this book on competitions).

The following engineering and science projects are described:
Electronic Wheel of Fortune
Baby Jacob's Ladder
Nerve Tester
Brainstorming (Courtesy of JETS)
Brainteasers (Courtesy of JETS)
What IZ It? (Courtesy of JETS)
Computer-Aided Design
Balloon Staging
Paper Rockets
Rocket Car
Rocket Pinwheel

Community Service Projects
In addition to the projects indicated above, posts should consider engaging in community service projects that meet a specific community need. Building a playground, helping the elderly winterize their homes, assisting in environmental cleanup, assisting a local MATHCOUNTS competition, and helping in recovery efforts after a natural or man-made disaster are but a few examples of appropriate community service projects.]

[[**DE**: Design a standard format for pages with projects or competitions. Each one has a name. Each one has subheads introducing different parts of the project, although wording of the subheads differs from project to project.]]

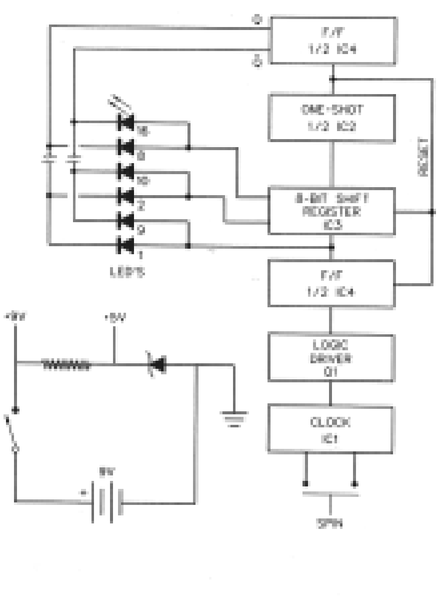
<u>Electronic Wheel of Fortune</u>
Project Description
The wheel of fortune has always been one of the favorite games of chance. Perhaps it is because of the fascination of watching the wheel go around and not knowing where it will stop. This electronic roulette game has little red lights going around and around, stopping eventually at a randomly selected number between 1 and 16. Players can select their numbers for each spin of the wheel, watch the lights, and collect their fortunes if the light

stops on their number. Like a mechanical wheel, the lights go fast at first and then slow down gradually before stopping at the winning number.

Basic electronic fabrication techniques are learned in the Electronic Wheel of Fortune project.

Requirements
Human resources: One Advisor; the number of associate Advisors depends on the number of Explorers participating. Electronics engineer as guest speaker.
Meetings: Four to eight meetings
Type of facility: Electronics laboratory
Project cost: $25 to $30
Materials: B1—9-volt battery (six cells)
- C1—0.22 HF capacitor
- C2—0.001 HF capacitor
- C3—100 HF 15-V electrolytic capacitor
- C4—0.03 HF capacitor
- D1—5.6-V zener diode
- 1C1—Function generator (566)
- 1C2—Quad 2-input NAND gate (7400)
- 1C3—8-bit shift register (74164)
- 1C4—Dual JK flip-flop (74107)
- LED 1 to LED 15—Light-emitting diode
- Q1—Silicon non transistor
- R1, R3–R5—10,000-ohm, 1/4-watt resistor
- R2—1,500-ohm, 1/2-watt resistor
- R6—39-ohm, 1/4-watt resistor
- R7—1,700-ohm, 1/4-watt resistor
- R8—180-ohm, 1/4-watt resistor
- S1—SPST switch
- S2—Normally open SPST push-button switch
- Suitable enclosure
- Press-on type
- C-cell holders
- Insulated wire
- Mounting hardware

ıtor (1C1) operates at about 100 Hz when the spin
e switch is released, a time constant in the circuit



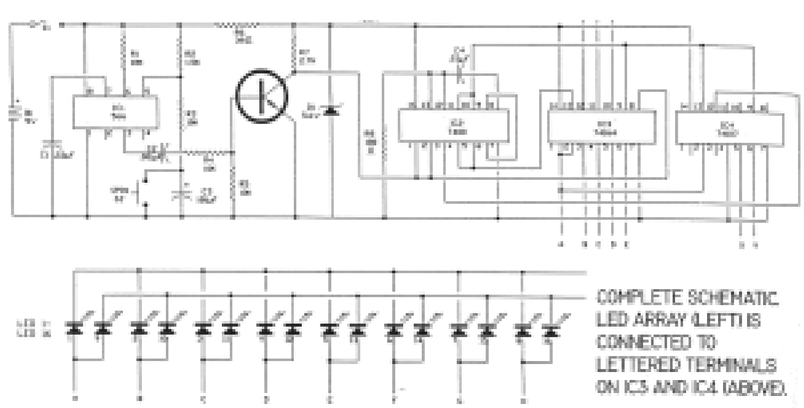


FIGURE 2

causes the oscillator to slow down to a stop in about 10 seconds. The output of the clock is conditioned for the TTL logic by transistor Q1.clock is conditioned for the TTL logic by transistor Q1.

To understand how the 16 LEDs are operated, note that the combinations of numbers 1 and 9, 2 and 10, etc., through 8 and 16 are driven by the output of the first flip-flop and the 8-bit shift register. However, the selection of which of the eight combinations is the circuit at one time is made by the state of the second flip-flop. As the clock delivers pulses to the first flip-flop, the digital one level is propagated from 1 through 8 on the LEDs.

At the eighth clock pulse, the output of 1C3 operates a one-shot (1C2). This causes the output flip-flop to change states, so that the second eight LEDs are selected. Simultaneously, the first flip-flop and the shift register are reset. In this way, the same logic is used for all 16 LEDs. The complete schematic is shown in figure 2.

Construction
Be sure to observe the polarities and coding on all components and use a low-power soldering iron. Note that there are three jumpers on the board.

The prototype was housed in a plastic enclosure 6-1/2 by 3-3/4 by 2 inches. The cover of the box was drilled for the 16 LEDs arranged in a circle. The holes should be just large enough to fit the tops of the LEDs. The lights can be identified at random, using press-on type. The two switches can be mounted on the cover.

Since the project has a current drain of about 100mA, six C cells, in holders mounted on the bottom of the enclosure, can be used. This allows about 10mA for the LEDs, but it is advisable to have a few extras so that they can be selected to have all 16 glow with about the same brilliance.

Fortunes
1. You will receive an unexpected sum of money.
2. You are going to lose some money.
3. You are going to make new friends who will greatly influence your life.
4. You will avoid a threatened illness.
5. Small risk, small gain, great risk, great loss.
6. Something is going to occur that will damage your reputation.
7. Some field of higher learning is going to help you reap a great reward.
8. Something you will do in connection with the nation's armed forces is going to win you great praises.
9. Proceed cautiously with whatever you are planning to do; there is bad luck ahead.
10. A streak of good luck is coming your way.
11. A friendship is going to blossom into love.
12. You are in danger of contracting a rare disease.
13. A heartache now will save a heartbreak later on.
14. Married life was intended for you and will bring you your greatest joy and satisfaction.
15. You are about to make a long journey.
16. A grave warning; you may be led into doing something that will involve some sort of punishment.
17. Happiness and good fortune beyond your wildest dreams are in store for you.
18. If you have any plans, pursue them with vigor. The time is ripe.
19. You are going to be troubled with many little problems.
20. You will meet a stranger at a party; it will be love at first sight.
21. You are about to suffer some sort of loss.
22. You will find a valuable article and will receive a fine reward for its return.
23. A long and healthy life is planned for you.

24. You are going to have trouble arising directly from a love affair.
25. A talent you have overlooked is going to prove very profitable to you.
26. You will suffer loss by theft, but that which is stolen will be returned.
27. An unpleasant duty lies ahead.
28. A proposal long awaited is going to take place.
29. A message is coming to you from the beyond.
30. Be on the lookout for an unpleasant experience connected in some way with water.

Baby Jacob's Ladder

Caution: Hazardous current is involved in this project.
Baby Jacob's Ladder

Project Description
Build a small Jacob's Ladder (high-voltage arc) for post display.
Requirements
Human resources: One Advisor for two to four Explorers; electronics engineer as guest speaker
Meetings: Two to four meetings
Facilities: Electronics laboratory
Project cost: $50
Materials: AC plug (for each participant)
High-voltage transformer wire (for each participant)
3/16-inch rods (for each participant)
Insulators (for each participant)
Clear plastic (for each participant)
Main enclosure—Use 20-gauge aluminum (fabricate as shown, using approximate dimensions). Three separate pieces may be used for convenience.
Mounting plate—Use 20-gauge aluminum (fabricate as shown, using hole location dimensions shown in sketch).
Cover—Fabricate as shown from thin aluminum. Ventilate the top for air flow.
Windows (2)—Use acrylic; be careful when drilling. Note access hole for adjustment of starter ionizer.
Transformer—5,000V at .02-amp current limited
Power switch and hardware—Toggle SPST 3 amp
Power cord—Three-wire molded, with ground
Small wire nut—For two #18 wires
Rubber feet (4)—Self-stick type
Ground wire—Not needed for #112 transformer
Sheet metal screws (6)—#6 x 1/4 type AB
Machine screws and nuts (12)—6-32 x 3/8-inch
Ladder elements—.3-inch wide, .02-inch thick pieces of copper strip. Shape and form as in the sketch.
Insulator standoff—5/8 conical steatite
Metal spacer—1/4-inch with hole for 6-32 screw
Element spreader—Plastic or perfboard 1/4-inch x 1-inch—RTV in place to position
Screws (2)—6-32 x 1/4-inch
Bushing—3/8-inch plastic
Starting ionizer—Small common pin, needle, or wire soldered as shown for initiating plasma

Construction
The Jacob's Ladder is assembled as shown in fabricated aluminum with an acrylic front and back cover that permit viewing but prevent curious fingers from receiving a moderate electrical shock. The only critical dimensions are the positioning of the ladder elements, along

with the "starting ionizer." The sketch is used as a guide for the position of these components. Dimensions of the overall assembly given in the sketches are only to be used as an approximate guide for fabrication.

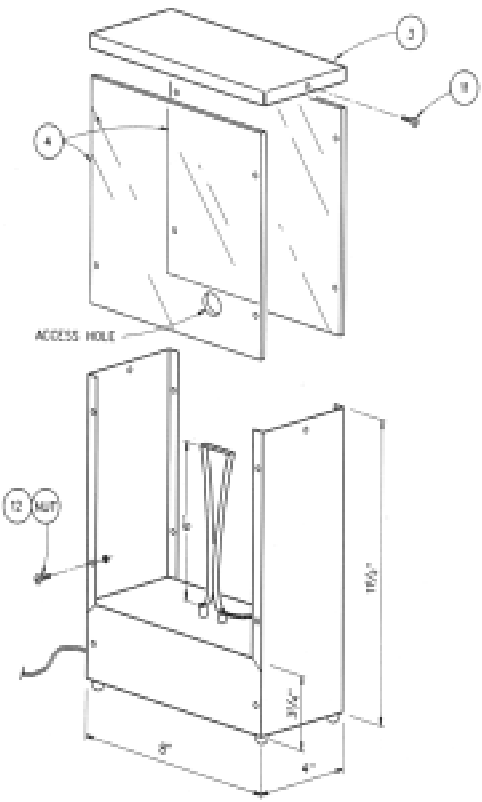


FIGURE I
"BABY JACOB"

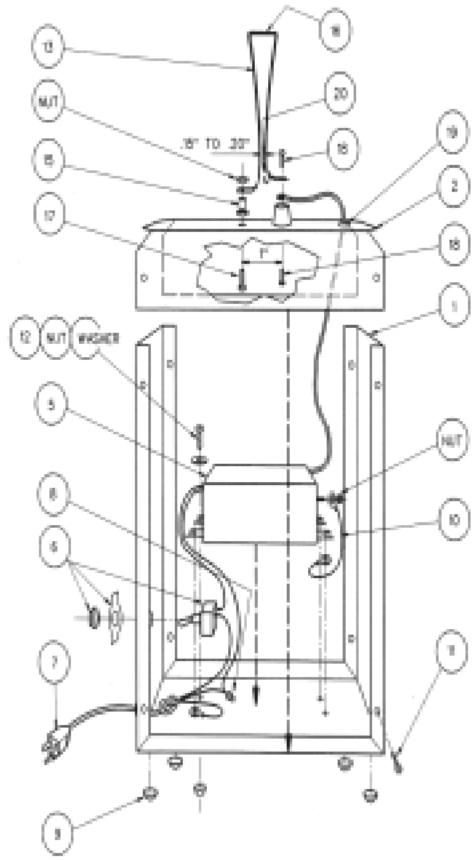
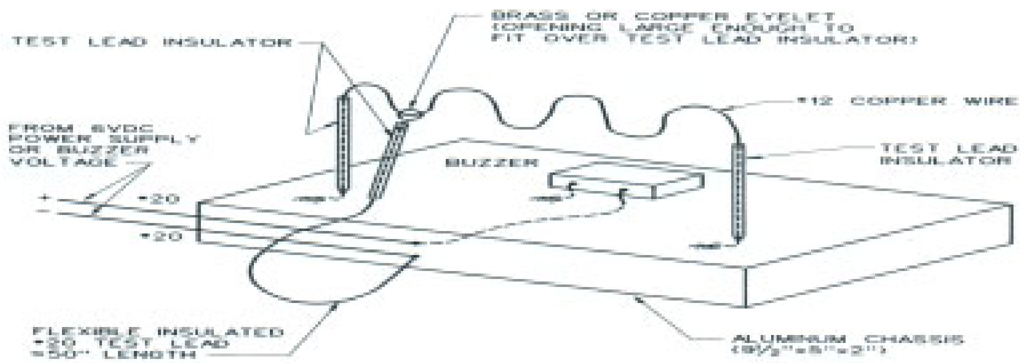


FIGURE 2
"BABY JACOB"

Apply power and check for arcing between the ladder elements. Use an insulated screwdriver and be careful. Adjust the point of the needle for continuing breakdown of initiating plasma that travels up the ladder elements and extinguishes. If the shape of the ladder elements shown in the sketch is followed and the needle is properly adjusted, an arc starting at the bottom should continually repeat itself going to the top of the ladder, extinguishing, and starting again all automatically. When the unit is cold, use the access hole to start it with an insulated screwdriver. Sometimes a light tap will start the unit.

Nerve Tester



NERVE TESTER

Brass or copper eyelet (opening large enough to fit over test lead insulator)
12-gauge copper wire
Test lead insulator
Aluminum chassis (9-1/2 x 5 x 2 inches)
Flexible insulated 20-gauge test lead (about 50 inches long)
From 6-volt DC power supply or buzzer voltage
20 gauge
Test lead insulator

Project Description
The project is for a post display. A person tries to get the brass eyelet from one insulator to the other without causing the buzzer to sound.
Requirements
Human resources: One Advisor, one to two Explorers
Meetings: Two to four meetings
Facilities: Electronics laboratory
Field trip: Electronics laboratory
Project cost: $20
Materials: One chassis per participant
Three test lead insulators per participant
One buzzer per participant
Wire for each participant
One power supply per participant

Brainstorming
Group effort is a very common approach to problem solving. In industry, groups of engineers and scientists will often meet in order to suggest possible solutions or alternatives to design problems and perhaps begin the solution process. These sessions are called "brainstorming" sessions. Explorers can also brainstorm. Below are ideas for discussion as well as an outline of the engineering design method which can be used as a

model for discussions. Participants are encouraged to research the topic and develop ideas and alternatives before the brainstorming session is to take place.

The Engineering Design Method

1. Define the problem.
2. Assess the needs and priorities.
3. Determine the scope and limitations and clarify restrictions.
4. Choose a theory or model by selecting the physical laws and engineering arts that would apply.
5. Generate alternative ideas.
6. Gather required information and complete a description of the elements of the proposed designs.
7. Evaluate the alternatives.
8. Refine the design of the best alternative.
9. Assess the side effects, consequences, and cost/benefit.

This outline is suggested as a format in approaching engineering discussion ideas as well as design and problem solving activities.

Example

Start a discussion about the redesign of public buildings to make them accessible to the physically handicapped. The law requires that all public buildings being planned or remodeled comply with special standards. The standards require wider doors that a wheelchair can fit through. Ramps should be built near stairs. Alterations to help blind and hearing-impaired people identify room numbers and other locations would be made. Engineers may see the problem in different ways. Instead of retrofitting buildings or widening doors, could a wheelchair be designed that could "climb" stairs and be thin enough to fit through existing doors? Can a standardized audio/tactile "map" be developed to coordinate maneuverability and locations? This is just a small sample of possible solutions to this problem. The next step is to research the available information and evaluate the alternatives.
Encourage discussion of all facets of engineering design—the problems, solutions, alternatives, and the social and economic ramifications of the design.

Discussion Ideas

Solid waste—Solid waste disposal is rapidly becoming one of the major environmental problems of this decade. Landfill sites are closing; environments are being polluted. From an engineer's perspective, what alternatives can be developed to alleviate this situation?
Automobile safety—The design of an automobile often contributes to the cause of an accident. From an engineer's perspective, how can these design flaws be corrected while still having an automobile that is attractive to the consumer?
Myoelectric prostheses—The electrical activity within an amputee's remaining muscle is used to control the movement of a prosthesis. Through engineering, how can more versatility of movement be achieved?
Space heating—In many parts of the United States, about 50 percent of domestic energy use is for space heating. One of the major causes of heat loss is doors and windows. Through engineering, can the design and materials of doors and windows be improved to reduce heat loss?
Fiber optics—The use of fiber optics is increasing daily. Not only are they used to transmit light for medical exploration, but they are replacing copper wire for communications. Through engineering, are there other applications for fiber optics?
Fire safety—Structure fires remain one of the most important national problems. What role can the engineer play in the science of fire prevention and fire fighting? In particular, discuss materials, fire detection, or fire-fighting equipment.

Community problems—Within any American community there may be several technological problems. The solutions to many of these problems (pollution, water shortage, urban blight, transportation congestion, energy generation, etc.) depend on the devices, designs, systems, and expertise of engineers. Isolate one problem and discuss alternative solutions:

Artificial heart
Robotics
Biomaterials
Acid rain
Computer-aided design
Synthetic fuels
Hybrid vehicles
Aids for the blind
Auto safety restraints
Building materials
Noise pollution
Energy use

Brainteasers

From Mental Jogging*

Introduction

Brainteasers consist of exercises designed to "stretch the imagination" and stimulate creative problem solving. A statement is given for which a number of answers are evoked from participants. There are no "right" or "wrong" answers. Any answer, no matter how "crazy" it may sound, is a correct answer; however, the answer should be relevant to the problem. Simply write down responses to the statements given below with as many answers as possible. The responses may be scored as indicated in the scoring section.

Example

Q: Six or more ways to make a reflecting surface

A:
1. Use tinfoil.
2. Get a kit from Edmund Scientific Company.
3. Polish it.
4. Pour liquid in a dish.
5. Use fine grit, finish with jeweler's rouge.
6. Deposit silver, aluminum, copper, etc., on surface.
7. Blow a soap bubble.
8. Rub with soft cloth.
9. Hand a plain piece of paper to Midas.
10. Apply nail varnish.
11. Take a surface and teach it to think.
12. Electrodeposition of metal, then rub down.
13. Stop disturbing the water.
14. Put glass on it.

Questions

1. Six or more ways to produce electricity
2. Seven or more reasons for not having computers
3. Six or more ways to move a vehicle without an engine
4. Nine or more uses of dust
5. Eight or more problems that had to be overcome to fly to the moon
6. Seven or more ways to carry ten wooden hangers

7. Six or more ways to light a fire
8. Seven or more ways to prevent a candle from burning down
9. Eight or more new uses for cellophane tape
10. Seven things you would have to change about your body to become a bird
11. Eight or more non-writing uses for a pencil
12. Seven or more novel uses for crushed ice
13. Six or more ways to avoid spilling coffee while driving
14. Six or more uses for the jet stream
15. Eight or more reasons for not exploring Mars

Scoring

1. For each answer up to the number requested, one point
2. For every answer over the number requested and under 25, two points
3. For answers 26–30, three points
4. For answers 31–50, four points

*Mental Jogging, Reid J. Daitzman, Richard Marek Publishers, New York, N.Y., 1980; 365 games to enjoy, to stimulate the imagination, to increase ability to solve problems and puzzles. Questions and examples are from Mental Jogging and used with permission of the author and publisher.

What IZ It?

Competition Statement

Each participant is to collect technological artifacts that are not easily identifiable and bring them to the competition site. The object of the competition is to challenge the technical IQ of participants in identifying the items.

Competition Parameters

Participants are encouraged to locate technological artifacts such as old automobile parts, electronic components, motor or engine parts, drafting equipment, tools, hydraulic components, etc. These items are often found in closets, attics, basements, garages, and storerooms of Explorers' homes. Sponsors, your school, and repair shops in your community may also be sources for old or outdated technological items.

Each item is to be introduced to the participants. The participants are to answer as many of the following questions about that item as possible:

1. What is the item?
2. How old is it?
3. What is its function?
4. What principles are employed?
5. Has it been replaced?
6. If so, by what?

Additional questions may be established for a particular item as necessary. A discussion of each item should follow the question period.
Points may be assigned for each question, with the participant who answers the most questions accurately and accrues the greatest number of points being declared the winner.

Computer-Aided Design (CAD)

AutoCAD design is always a popular event.

Participation

Minimum: Two Explorers
Maximum: Three Explorers

Scenario

Teams will be challenged to produce an engineering design using computer-aided drafting software. Practicing on CAD-type software and a mouse on the computer is encouraged as a post activity. The judging will be done by engineering students and local engineering professionals.

Balloon Staging

Objective

To demonstrate the principle of rocket staging.

Description

In this activity, Explorers simulate a multistage rocket launch using two inflated balloons that slide along a fishing line by the thrust produced from escaping air.

Procedure

1. Thread the fishing line through the two straws. Stretch the fishing line snugly across a room and secure its ends. Make sure the line is just high enough for people to pass safely underneath.
2. Cut the coffee cup in half so that the lip of the cup forms a continuous ring.
3. Loosen the balloons by pre-inflating them. Inflate the first balloon about three-fourths full of air and squeeze its nozzle tight. Pull the nozzle through the ring. While someone assists you, inflate the second balloon. The front end of the second balloon should extend through the ring a short distance. As the second balloon inflates, it will press against the nozzle of the first balloon and take over the job of holding it shut. It may take a bit of practice to achieve this.
4. Take the balloon to one end of the fishing line and tape each balloon to a straw. The balloons should be pointed along the length of the fishing line.
5. If you wish, do a rocket countdown and release the second balloon you inflated. The escaping gas will propel both balloons along the fishing line. When the first balloon released runs out of air, it will release the other balloon to continue the trip.

Discussion

Traveling into outer space takes enormous amounts of energy. This activity is a simple demonstration of rocket staging that was first proposed by Johann Schmidlap in the 16th century. When a lower stage has exhausted its load of propellants, the entire stage is dropped, making the upper stages more efficient in reaching higher altitudes. In the typical rocket, the stages are mounted one on top of the other. The lowest stage is the largest and heaviest. On the space shuttle, the stages are attached side by side. The solid rocket boosters are attached to the sides of the external tank. Also attached to the external tank is the shuttle orbiter. When exhausted, the solid rocket boosters are dropped. Later, the external tank is dropped as well.

Teaching Notes and Questions

- Several launchings may be necessary to get the second "upper stage" balloon to travel completely across the room.
- Encourage the Explorers to try other launch arrangements such as side-by-side balloons and three stages.
- Can a two-stage balloon be flown without the fishing line as a guide? How might the balloon be modified to make this possible?

Materials and Tools

Two long party balloons ("airship")
Nylon monofilament fishing line (any weight)
Two plastic straws (milkshake size)
Styrofoam coffee cup
Masking tape

Scissors

Paper Rockets
Objective
To demonstrate the importance of using control systems, such as fins, to stabilize rockets in flight.

Description
In this activity, Explorers construct small flying rockets out of paper and propel them by blowing air through a straw.
Procedure
1. Cut a narrow rectangular strip of paper about 13 centimeters long and roll it tightly around the fat pencil. Tape the cylinder and remove it from the pencil.
2. Cut points into one end of the cylinder to make a cone and slip it back onto the pencil.
3. Slide the cone end onto the pencil tip. Squeeze and tape it together to seal the end and form a nose cone (the pencil point provides support for taping). An alternative is just to fold over one end of the tube and seal it with tape.
4. Remove the cylinder from the pencil and gently blow into the open end to check for leaks. If air easily escapes, use more tape to seal the leaks.
5. Cut out two sets of fins using the pattern on the drawing and fold according to the instructions. Tape the fins near the open end of the cylinder. The tabs make taping easy.

Flying the Paper Rocket
Slip the straw into the rocket's opening. Point the rocket in a safe direction and blow sharply through the straw. The rocket will shoot away. **Caution: Be careful not to aim the rocket toward anyone because the rocket could poke an eye.**

Discussion
The paper rocket activity demonstrates how rockets fly through the atmosphere. A rocket with no fins is much more difficult to control than a rocket with fins. The placement and size of the fins is critical to achieving adequate stability while not adding too much weight.

Teaching Notes and Questions
- Try flying a paper rocket with the fins placed on the front end of the cylinder. Also try attaching delta-shaped wings to achieve gliding flight.
- How small can the fins be made and still stabilize the rocket? How many fins are required?
- What will happen to the rocket if the lower tips of the fins are bent pinwheel fashion?
- Test fly different paper rockets to see which will travel higher or farther. Investigate the designs of the rockets that travel the farthest and shortest distances. What makes one rocket perform better than another? (Do not forget to examine the weight of each rocket. Rockets made with extra tape and larger fins weigh more.)
- Are rocket fins necessary in outer space?

Materials
Scrap bond paper
Cellophane tape
Scissors
Sharpened fat pencil
Milkshake straw (slightly thinner than pencil)

Rocket Car
Objective
Newton's Third Law of Motion is demonstrated with escaping air as the action force.

Description
In this activity, Explorers construct a balloon-powered rocket car that rolls across the floor because air is forced to escape through a plastic straw.

Procedure

1. Using the ruler, marker, and drawing compass, draw a rectangle about 7.5 by 18 centimeters and four circles 7.5 centimeters in diameter on the flat surface of the meat tray. Cut out each piece.
2. Inflate the balloon a few times to stretch it. Slip the nozzle over the end of the flexible straw nearest the bend. Secure the nozzle to the straw with tape and seal it tight so that the balloon can be inflated by blowing through the straw.
3. Tape the straw to the car as shown in the picture.
4. Push one pin into the center of each circle and then into the edge of the rectangle as shown in the picture. The pins become axles for the wheels. Do not push the pins in snugly because the wheels have to rotate freely. It is OK if the wheels wobble.
5. Inflate the balloon and pinch the straw to hold in the air. Set the car on a smooth surface and release the straw.

Discussion
The rocket car is propelled along the floor according to the principle stated in Isaac Newton's Third Law of Motion. The escaping air is the action, and the movement of the car in the opposite direction is the reaction. The car's wheels reduce friction and provide some stability to the car's motion. A well-designed and constructed car will travel several meters in a straight line across a smooth floor.

Teaching Notes and Questions• Encourage Explorers to design their own cars. Cars can be made long or short, wide or narrow, or even trapezoidal. Wheels can be large or small. If Styrofoam coffee cups are available, the bottoms can be cut off and used as wheels.

• Hold car distance trials on the floor. Have Explorers measure and chart the distance each car travels. Average multiple runs for individual cars to identify the best cars. What makes one car design perform better than another? Are large wheels better than small wheels?

Materials and Tools
Four pins
Styrofoam meat tray
Cellophane tape
Flexible straw
Scissors
Drawing compass
Marker pen
Small party balloon
Ruler

__**Rocket Pinwheel**__
Objective
To demonstrate Newton's Third Law of Motion using air escaping from a balloon as the action force.

Description
In this activity, Explorers construct a balloon-powered pinwheel that spins from the force of air escaping through a plastic straw.

Method

1. Inflate the balloon to stretch it out.
2. Slip the nozzle end of the balloon over the end of the straw farthest away from the flexible bend. Use a short piece of plastic tape to seal the balloon to the straw. The balloon should inflate when you blow through the straw.
3. Bend the opposite end of the straw at a right angle.
4. Lay the straw and balloon on an outstretched finger to find the balance point. Push the pin through the straw at the balance point, into the pencil eraser, and into the wood itself.
5. Spin the straw a few times to loosen up the hole the pin made.
6. Inflate the balloon and let go of the straw.

Discussion
The balloon-powered pinwheel spins because of the action-reaction principle described in Newton's Third Law of Motion. The air, traveling around the bend in the straw, imparts a reaction force at a right angle to the straw. The result is that the balloon and straw spin around the pin in the opposite direction.

Teaching Notes and Questions

- The activity can be done by every Explorer.
- Some toy and variety stores sell an inexpensive balloon-powered helicopter. The device has three small plastic wings through which air passes and is released in a right angle direction at each blade tip. Try to obtain one or more of these toys for comparison with the balloon pinwheel. The toy is marketed under the name of Whistle Balloon Helicopter. One of these helicopters was used by astronauts on the STS-54 space shuttle mission during the Physics of Toys live lesson.

Materials
Wooden pencil with an eraser on one end
Straight pin
Round party balloon
Flexible soda straw
Plastic tape

Competitions

Introduction. Competitions can stimulate interest and challenge post members. However, care should be taken to maintain a balance between competitions and other activities and projects during the program year. As noted earlier, many engineering and science projects can be adapted to competition format as well.

The following competitions are described in this section:

Straw Tower
Egg Drop
Bridge Building
Paper Airplane Design and Flight
Propelled or Unpropelled Vehicle
Windmill Windup (Courtesy of JETS)
Hand Power Winch (Courtesy of JETS)
Lord Kelvin's Water Drop (Courtesy of JETS)
Greatest Magnet (Courtesy of JETS)
Missile Launch (Courtesy of JETS)
Clay Boats (Courtesy of JETS)
Communication Challenge

Straw Tower

Project Description

An individual or a team of two Explorers design and construct a straw tower that will support a coffee can filled with sand. The tower that supports the most weight in the coffee can is the winner.
Here cans of tuna are used to test ultimate load capability. Competition and small prizes add fun to these events.

Materials Required

Each individual or team is given 100 plastic drinking straws, 100 straight pins, an X-Acto knife, and 50 paper clips.

Construction

Each tower is to be constructed from 100 or fewer plastic drinking straws. The straws may be cut to any length. Paper clips and common straight pins are to be used as fasteners. No more than one pin or one paper clip is to be used in connecting any two straws. No other materials are permitted. The top of the tower must have a surface sufficient to hold a 1-pound coffee can. The tower must be at least 0.5 meters high and must be able to support a minimum load of 250 grams.

Judging

In the first round, a coffee can containing sand (250 grams) will be placed by turn on top of each tower. The tower must hold the can for 10 seconds. All towers that survive a given round of testing pass into the next round. In each round, an additional 250 grams of sand will be added to the coffee can. The rating for each tower is the product of the heaviest load it supported (measured in grams) and the height of the tower (in meters). Towers may not be repaired between rounds.

Considerations

- What kind of design will provide strength and height at the same time?
- How big must the base be in order to make the tower stable?
- Are all joints the same? Are pins better for some and paper clips better for others?

Egg Drop

Project Description

An individual or a team of two Explorers design and construct a shipping container that will prevent an uncooked egg from breaking when dropped from a 10-meter height.

Materials Required

There are no construction materials limitations. The eggs should be grade A large chicken eggs provided by the Advisors.

Construction

The container must be less than 400 cubic centimeters in volume, with no dimension larger than 25 centimeters. Maximum weight including the egg cannot exceed 1,000 grams. Contestants must be able to remove the egg without damage. A maximum of 30 seconds will be allowed to place the egg in the container and the same to remove it.

Judging

Each model will be measured, weighed, and drop tested from a 10-meter height. Each model will be evaluated as follows:

[[Top line of formula centered over the W plus symbol L plus symbol X. See the attached go-by]]
75 x S
[[Bottom line of formula]]
V = (W [[plus symbol]] L [[plus symbol]] X)
Where:
V = Value
W = Weight (grams)
L = Longest dimension (centimeters)
X = Volume (cubic centimeters)
S = Success factor
(S = 100 if the egg does not break)
(S = 0 if the egg breaks)

Variation
Design a package to keep three uncooked eggs from breaking when dropped from a height of 2.5 meters. The volume of the package cannot exceed 1,600 cubic centimeters.

Bridge Building

Project Description
An individual or a team of two Explorers will design and construct a model bridge out of balsa wood and glue. Each bridge is tested for structural efficiency by applying a load to the bridge until failure occurs. The bridge with the highest structural efficiency (maximum load supported/mass of bridge) is the winner.

Materials Required
Three long sticks of balsa wood with identical lengths should be provided to each participant. Identical bottles of glue, a ruler, and an X-Acto knife should also be provided. This guarantees that each participant has identical materials and wood density in designing the bridges.

Construction
Models shall be constructed entirely of balsa wood bonded by the glue provided. No other materials, fasteners, or glues may be used. It is against the rules to coat the wood with glue.
Design criteria should be provided (example):

- Span to be bridged: 10 inches
- Maximum length of bridge: 12 inches
- Minimum width of bridge: 1 inch
- Maximum width of bridge: 2 inches
- Loading pad: 1 inch by 1 inch
- Abutment pads: 1 inch long by the width of bridge
- Maximum total depth of bridge: 6 inches

Judging
A load is applied to the bridge by adding weight on the rod at midspan from the highest point of the bridge on the loading pad. It is encouraged to use a university or business's compression tester to judge with an accurate scale the pounds of pressure applied. Bridges will continue to be loaded with additional pressure until failure or a maximum deflection of 2 inches is reached. The winning bridge is the bridge that supports the greatest load.

Paper Airplane Design and Flight

Participation
Individual
Tours of aircraft manufacturers, flight simulators, or maintenance facilities, or talks by professional pilots are ideal companions to this project.
A packet of materials including a sheet of paper and four paper clips will be given to each competitor. Thirty minutes will be given to design and construct an airplane from the given materials; a limited amount of tape may also be used to hold the airplane together, but other materials such as cardboard, wood, etc., are not allowed. The airplane must be launched by hand; no mechanical or electrical launching device may be used.

Note: Simply wadding up a piece of paper does not demonstrate suitable design practice and is not allowed. Sorry!
The paper airplanes will be judged in three categories: accuracy of flight, time aloft, and distance traveled. The overall winners will be judged on the best combined scores of all three categories.

<u>Propelled or Unpropelled Vehicle</u>

Design Statement
Design and build a propelled or unpropelled vehicle that will perform in a specified manner.
Propulsion
The vehicle may be designed as unpowered or powered. The source of propulsion may include a mouse trap, a spring or spring mechanism, one or more rubber bands, a balloon, or any combination of the four.
Load
The vehicle may be designed to transport a given load from an uncooked egg, to a given set of weights, to being unloaded.

Track
The track should be appropriate for the propulsion method and load. An unpowered vehicle will need to travel down an inclined track; a powered vehicle might even be required to climb or run up an incline.
Object
The object can range from going the farthest, to going the fastest, to covering a distance the most precisely and stopping the closest to a preset objective, or even clinging to a level and staying for a specified time.
Materials
The materials list can range from a limited proscribed list to a dollar limit on expenditure. The propulsion source must always be clearly identified.
Test Track
The track can range from an inclined plane, to a flat surface with guides on the side, to a plastic vertical pipe or an inclined screen mesh. For a good competition, the specific track must be well defined and available to the contestants for trial runs to test their designs.

Contest Rules for Judging Performance
A set of rules should include how the vehicle will be started, how it must move (i.e., stay on the track) and how the winner will be determined.

Prizes For
1. Fastest/farthest/highest/longest
2. Most accurate performance
3. Best design
4. Most imaginative
5. Best implementation
6. Best quality

7. Lowest cost

Windmill Windup

Helix rotor
Savonius rotor
10 cm
20 cm
24 cm

Figure 2
1/2 meter
Timing zone
2 meters

Design Statement
Design and build a wind machine that will carry a weight across a horizontal distance in the shortest possible time.

Design Parameters
The wind machine must fit within a box 24 by 10 by 20 centimeters high and must use a wooden vertical axis. It must be mounted on a stand so that the axle will be in a position to wind up a cord to which a weight (a silver dollar) has been attached. Possible designs are shown in figure 1. Collapsible vanes or vanes with moving parts may also be used.

Materials Limitations
There are no construction materials limitations for the wind vanes or collectors. The vertical wooden axle is made of a 3/16-inch dowel no longer than 30 centimeters. A 4-meter cord will be attached to the axle or take-up spool.

Testing Conditions
Place the wind machine on the floor in front of a fan. Mark out the 2-meter timing zone as shown in the illustration. The contestants may vary the height of the wind machine as desired. The distance from the fan will not vary. Stretch the cord from the machine axle across the timing zone. Tape a silver dollar to the end of the string 1/2 meter from the timing zone. Upon a judge's start signal, the contestant will allow the wind machine to start. The time it takes for the coin to pass across the 2-meter timing zone after the initial 1/2-meter "start-up" zone will be recorded. The machine requiring the least travel time through the 2-meter zone will be declared the winner. See figure 2.

Note: A study of types of windmills—American multiblade, Dutch four-arms, high-speed propeller, Savonius, Flettner, Stuart propeller-type, etc.—prior to designing the project model may be advantageous to the Explorers.

Hand Power Winch

Design Statement
Design and build a power winch that will lift the greatest weight 30 centimeters with the push or pull of a soda straw.

Design Parameters
The winch cannot be larger than 25 centimeters in any direction (25 by 25 by 25 centimeters). The loading line must pass through the center of the bottom surface to lift a load vertically (figure 1). The base of the winch must be 25 by 25 centimeters for mounting.

Any mechanical technique—jacking, gears, friction, etc.—may be used to lift the weight. Power will be limited to the push or pull of a soda straw moved through an 8-centimeter maximum distance on each stroke (figure 2). The contestant's hand may not hold the straw closer than 8 centimeters from the point at which it is attached or is in contact with the device. Straws may be attached in any manner but must be exchangeable with new straws issued by the judges at testing. These straws may be adapted to the connection point only. No reinforcement of the straw will be permitted.

Materials Limitations
Only wood, string, Styrofoam, plastic, paper clips (No. 1 or No. 2 size), rubber bands (No. 64 or smaller—1/4 inch wide by 3-1/2 inches long when unstretched), model cement, lubricants, and a 6-millimeter diameter plastic soda straw (McDonald's, Burger King, etc.) may be used.

Testing Conditions
After the winch is placed in the testing stand, the contestant will power the winch by hand with the soda straw for each weight trial. Contestants will be allowed two minutes for each lift—one trial for each weight. A contestant may enter at any weight level as the weights are increased. Entry at the first level is not required. The weights will be increased until a winner is declared.

Lord Kelvin's Water Drop

Water tank
Control device
1 meter
No. 16 metal cans
Bulb
Wire rings and connections

Design Statement
Design and build a system that will light a neon bulb the most times in a 60-second period using Lord Kelvin's water drop principle.

Design Parameters
The apparatus must be mounted so as to be a one-piece mechanism with a 1-meter maximum height as a constraint. The cans may be movable and the rings adjustable. A typical system might appear as the one in the illustration.

Materials Limitations
A water tank with two outlets to accommodate a hose or tube, control devices or valves for hoses, metal cans, and wire. A neon bulb with 25-centimeter wire leads with metal friction clamps on the ends may be supplied by the judges or the contestants.

Testing Conditions
The contestant will be allowed adjustments prior to test runs. A two-minute start-up period or less will be permitted as a warm-up. The test run will begin with the contestant saying "Three, two, one, start." The judge will start a 60-second timer and count the number of times the light is illuminated. In case of ties, additional runs may be made.

Note: Before beginning this project, it is advisable to research electrostatic principles and, specifically, the Kelvin water dropper.

Greatest Magnet

Design Statement
Design and build an electromagnet with the greatest magnetic force to pick up the most weight of iron nails.

Design Parameters
The electromagnet should not be larger than 5 by 5 by 5 centimeters. One surface will have a hook or loop for hanging which may extend beyond the 5-centimeter height as shown in the illustration. The opposite surface will be the magnetic pickup. The magnet will be powered from a 12-volt DC source, and two electrical leads may be attached anywhere on the magnet.

Materials Limitations
The two electrical leads should be at least 20 centimeters long with appropriate connectors to the power source. There are no other construction materials limitations.

Testing Conditions
The magnet will be connected to the 12-volt DC source and judged on the basis of the weight of iron nails (or other magnetic material) that can be lifted.

Missile Launch

Target, 1.6-meter diameter
9 meters
3 meters

Launch area
15 meters
5 meters
10 meters

Design Statement
Design and build a vehicle that will travel a distance and, while moving, automatically launch a pencil missile at a target.

Design Parameters
The vehicle must fit inside a rectangular box 30 centimeters wide, 60 centimeters long, and 60 centimeters high and may be powered by any means. The vehicle must start from a standstill without the aid of supports or backstop. No push or pull starts are allowed.
The missile must be constructed from a pencil and mounted on the vehicle at a 45-degree or greater angle to the floor and fired automatically. An additional power source may be used in the missile launcher design.

Materials Limitations
There are no construction materials limitations for the launch vehicle.
Almost any power source may be used—electrical, batteries, clock spring, rubber band, etc. No chemical or explosive devices may be used.
The missile must be made from a standard yellow wooden pencil which may not be shortened to less than 15 centimeters. Fins may be added, but the eraser must not be modified. Grease will be applied to the eraser to mark the impact point.

Testing Conditions

The vehicle will be tested on a smooth floor on which the boundaries shown in the illustration have been marked. The vehicle must start from a standstill, proceed to the launch area, and automatically fire the missile at the target while moving. The vehicle must remain in bounds at all times until after the launch. Each contestant will have two official runs. The missile whose impact point is closest to target will be declared the winner.

Variation—Spring Pong Launch
Design and build a device that will carry and launch a pingpong ball. The vehicle will be propelled and the ball launched by two standard alarm clock springs or two mouse trap springs or one of each in any combination. There are no other materials limitations. The device is to be set in motion on a starting line and carry the pingpong ball two meters before launching the ball toward the target. The ball landing closest to the target will be declared the winner.

Clay Boats

Design Statement Teams of two will design and build clay boats that will withstand the most added weight before sinking.

Design Parameters
The team will have 15 minutes to construct two clay boats. There are no restrictions for the boat size, weight, or design; however, no devices (rolling pins, etc.) may be used to shape or form the boats. Weights will be added until the boat sinks.

Materials Limitations
Two 125-gram packages of Plasticine or non-water soluble modeling clay are the only construction materials used. Team members may pool their clay. A soda straw, weights, and a large container of water are necessary for the testing procedure.

Testing Conditions
Float one of the boats in the container of water. One member of the team will add uniform weights one at a time until the boat sinks, while the second team member keeps the boat from touching the sides of the container with the soda straw. As the boat becomes sinkable, the judge will request that a second or more elapse between the weight additions. The test will be repeated for the second boat. The winner will be based upon the mass of the weight added before the boat sinks. The weights will be dried and weighed after each trial. The team score will be determined by the sum of the added mass for the two entries, with the highest being declared the winner. A tie will be broken by giving the teams 110 grams of clay to construct one boat. Repeat the testing procedure.

Communication Challenge

Project Description
This event challenges each future engineer's ability to communicate with fellow Explorers. The event will assess their aptitude to write procedures for others to build a given object and follow someone else's written procedures as well.
[[**DE**: Art 46 and 47 complement each other and could run together with one cutline.]]
In the Communication Challenge, one team describes an object and takes it apart. A second team tries to rebuild it from the written description.

Materials Required

Participation is by two- or four-member teams with an approximate time of two hours. Each individual or team is shown a contraption built from blocks, science equipment, Tinkertoys, Legos, Lincoln Logs, K'Nex or other materials.

Construction

The Advisors should construct an object that is identical for each team. The object should remain hidden until the competition is ready to begin and then is presented to one member of each team at the same time. The Explorer has 45 minutes to write a description of the object and instructions on how to rebuild it. The Explorer then disassembles the object and leaves the individual pieces and instructions for his/her partner waiting in another room. The partners switch places. The partner who had been waiting takes the description and attempts to re-create the original object in 40 minutes or less. No diagrams, pictures, codes of any kind, or abbreviations for units such as "cm" for centimeter are allowed. The description needs to be in sentence or phrase format.

Judging

The Explorer who builds the object nearest to the original is declared the winner. A point will be given for each piece of material correctly placed in the proper location. Teams that use diagrams, codes of any kind, or abbreviations for units will be disqualified. Time will be used as a tie-breaker so everyone should start rebuilding the objects at the same time. Time is noted when they are finished.

APPENDIX 1

National Society of Professional Engineers Code of Ethics for Engineers

Preamble
Engineering is an important and learned profession. As members of the profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness and equity, and must be dedicated to the protection of the public health, safety and welfare. Engineers must perform under a standard of professional behavior which requires adherence to the highest principles of ethical conduct.

Fundamental Canons
Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health and welfare of the public
2. Perform services only in areas of their competence
3. Issue public statements only in an objective and truthful manner
4. Act for each employer or client as faithful agents or trustees
5. Avoid deceptive acts
6. Conduct themselves honorably, responsibly, ethically and lawfully so as to enhance the honor, reputation and usefulness of the profession

Engineer's Creed

As a Professional Engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare.

I pledge:

To give the utmost of performance;

To participate in none but honest enterprise;

To live and work according to the laws of man and the highest standards of professional conduct;

To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations.

In humility and with need for Divine Guidance, I make this pledge.

Adopted by
National Society of Professional Engineers
June 1954

APPENDIX 2

Engineering Societies

Accreditation Board for Engineering Technology, Inc. (ABET)
www.abet.org

American Academy of Environmental Engineers (AAEE)
www.enviro-engrs.org

American Association of Engineering Societies (AAES)
www.aaas.org

American Congress on Surveying and Mapping (ACSM)
www.acsm.net

American Consulting Engineers Council (ACEC)
www.acec.org

American Institute of Aeronautics and Astronautics (AIAA)
www.aiaa.org

American Institute of Chemical Engineers (AIChE)
www.aiche.org

American Nuclear Society (ANS)
www.ans.org

American Society for Engineering Education (ASEE)
www.asee.org

American Society of Certified Engineering Technicians (ASCET)
www.ascet.org

American Society of Civil Engineers (ASCE)
www.asce.org

American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
www.ashrae.org

American Society of Mechanical Engineers (ASME)
www.asme.org

American Society of Naval Engineers, Inc. (ASNE)
www.navalengineers.org

American Society of Plumbing Engineers (ASPE)
www.aspe.org

American Society of Safety Engineers (ASSE)
www.asse.org

Illuminating Engineering Society of North America (IESNA)
www.iesna.org

Institute of Electrical and Electronics Engineers Inc. (IEEE)
www.ieee.org

Institute of Industrial Engineers (IIE)
www.iienet.org

Institute of Transportation Engineers (ITE)
www.ite.org

Junior Engineering Technical Society (JETS)
www.jets.org

(The) Minerals, Metals & Materials Society (TMS)
www.tms.org

National Academy of Forensic Engineers (NAFE)
www.nafe.org

National Science Foundation (NSF)
www.eng.nsf.gov

National Society of Professional Engineers (NSPE)
www.nspe.org

Society of Allied Weight Engineers, Inc. (SAWE)
www.sawe.org

Society of American Military Engineers (SAME)
www.same.org

Society of Automotive Engineers (SAE)
www.sae.org

Society of Fire Protection Engineers (SFPE)
www.sfpe.org

Society of Manufacturing Engineers (SME)
www.sme.org

Society of Naval Architects & Marine Engineers (SNAME)
www.sname.org

Society of Plastics Engineers Inc. (SPE)
www.4spe.org

Society of Women Engineers (SWE)
www.swe.org

System Safety Society (SSS)
www.system-safety.org

Scientific Societies

American Association for the Advancement of Science (AAAS)
www.aaas.org

American Chemical Society (ACS)
www.acs.org

(The) American Physical Society (APS)
www.aps.org

National Academy of Sciences (NAS)
www.national-academies.org

Professional Societies

The American Institute of Architects (AIA)
www.aia.org

American Planning Association (APA)
www.planning.org

American Public Works Association (APWA)
www.apwa.net

American Society of Landscape Architects (ASLA)
www.asla.org

American Water Works Association (AWWA)
www.awwa.org

Water Environment Federation (WEF)
www.wef.org

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