TEAMS 2004 PROBLEM STATEMENTS

The following are the preliminary Problem Statements and the initial Background material for the 2004 TEAMS Competition. They may be edited and expanded in the final document; however, the thrust of the problems will remain the same. Also, the order of the problems shown here are not necessarily the order to be presented in the final copy. Students are advised to research terms that they are unfamiliar with prior to the competition.

1. TITLE: FIRE PROTECTION ENGINEERING

PROBLEM STATEMENT:
An insurance company for a large bank has hired your Fire Protection Engineering firm to provide consulting services for a suspicious fire in the bank's headquarters' building. Your team must investigate the causes and sources of a fire.

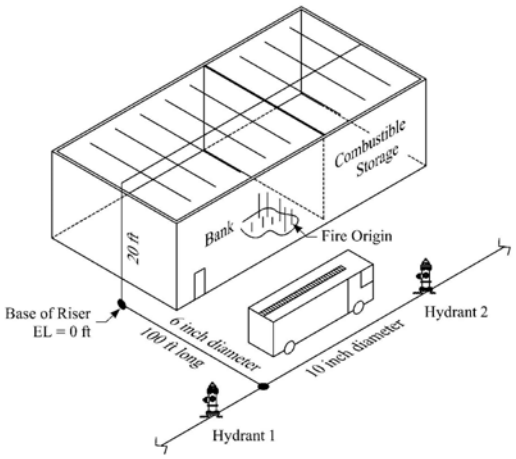


Figure1-1Diagram of Facility and Fire Origin

BACKGROUND:
While only a small portion of the work performed by Fire Protection Engineers, fire reconstruction is a common task. Fire Protection Engineers use calculations to determine time of ignition, flame height, time until flashover, and materials contributing to a fire. In addition, calculations allow Fire Protection Engineers to determine the adequacy of suppression systems and possible malfunctions. This ultimately allows engineers to make conclusions about how a fire began. Also, this information is used to determine if specific factors, such as a properly working sprinkler system could have changed the outcome of the fire.

2. TITLE: HYDROSTATIC BEARING

PROBLEM STATEMENT:
Your consulting firm has been hired to design bearings that will be used to support the weight of a telescope, while allowing rotation about the azimuthal (vertical) axis. Because of the need for easy motion with such a large load, the sliding resistance must be very low. The goal is to provide specifications that will allow for the required load to be completely supported by a thin pressurized oil film.

BACKGROUND:
Consider the Figure 2-1, which depicts the geometry of an individual bearing that will be used in conjunction with other bearings to support the telescope. Each bearing has a circular in cross-section as shown. A total of 8 bearings are to be arranged in an octagonal configuration, with each supporting 1/8 of the total load. In a hydrostatic bearing, pressurized fluid, usually oil, is pumped into the interface between the runner (the moving half of the bearing) and the stationary counter surface. When operating properly, a gap is developed between the solid surfaces, referred to as the film thickness. This mode of lubrication is known as "full-film" lubrication because a film of fluid completely fills the space between the solids. On the way to the interface, the oil flows through a restrictor, a device that affects how the pressure builds up as the pressure decreases. As the oil flows into the interface, it first enters the recess area and then flows radially outward. Eventually the oil flows ("leaks") out of the interface. Because of the radial leakage, the oil must be continually supplied.

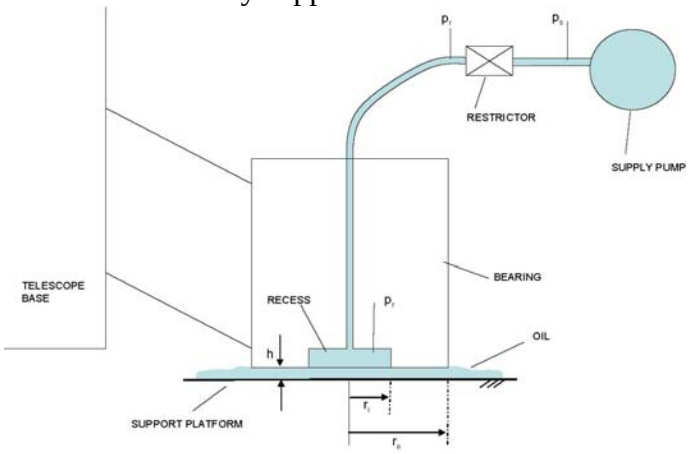


Figure 2-1: Schematic of the hydrostatic bearing.

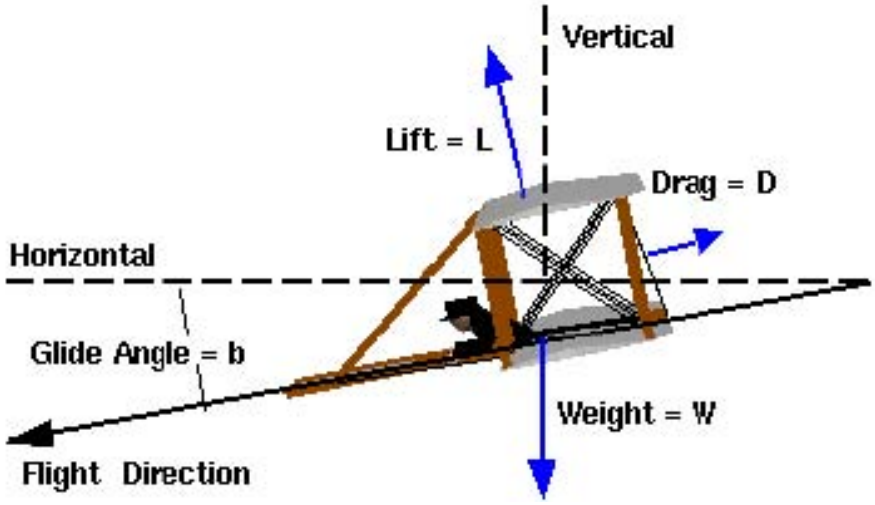
3. TITLE: DESIGN OF A FLYING MACHINE

PROBLEM STATEMENT:
Your engineering team has been asked to assist two bicycle mechanics from Dayton, Ohio, in the design and analysis of a flying machine.

BACKGROUND:
The date is June 1, 1900. Wilbur and Orville Wright have decided to make a "small contribution" to the study of flying machines by designing a manned glider, which can be controlled by the pilot. The brothers have written to the Smithsonian research agency and have received some technical papers from Samuel Langley, Otto Lilienthal, and Octave Chanute which describe how flying machines work.

Chanute's paper explains that flying is a delicate balancing act between forces acting on the aircraft (See Figure3-1). To fly, one must generate a lift (L) force, which overcomes the combined weight (W) force of the aircraft, the pilot, and the payload. The lift is generated by the wings of the aircraft as they move through the air. But the air produces a resistance to the motion, which is called the drag (D) force. Forces are vectors, having a magnitude and a

direction, and the direction is important. Weight is always directed towards the center of the earth. Lift and drag are defined relative to the flight direction; drag is opposed to the flight direction and lift is perpendicular to the flight direction. To overcome drag, one must do work on the aircraft. A powered aircraft uses a propulsion system to overcome drag, but a gliding aircraft uses gravity (or rising air masses) by trading altitude for velocity. A glider is constantly descending in flight. The flight direction of a glider is inclined to the horizontal at an angle, which is called the glide angle (b).



4. TITLE: ENGINEERING IN FAST FOOD PROCESSING

PROBLEM STATEMENT:
Your engineering team has been asked to follow the physics of a fast food facility from the freezer to the fryer with a few food-processing functions along the way.

BACKGROUND:
The operation of a fast food restaurant provides numerous opportunities to apply physics and food chemistry. Hot foods must be kept hot and cold foods cold to prevent the growth of dangerous bacteria. Getting you the hot meal you ordered fast means a lot of systems have to function correctly all the time. Let's investigate what goes on behind the counter. In particular, it will be necessary to investigate heat flow considerations in the storage and processing of a fast food product.

5. TITLE: NUCLEAR REACTOR INVESTIGATION

PROBLEM STATEMENT:
Your engineering team has been given the responsibility of investigating the use of nuclear reactors for producing energy.

BACKGROUND:
Among the identifying features of Nuclear Engineering is the nuclear reactor. Fundamentally, the reactor has one of two purposes:
1. It produces neutrons, electrically neutral particles with a mass of approximately 1 atomic mass unit (amu), and

2. It produces heat, allowing us to convert some of the heat energy into electricity.

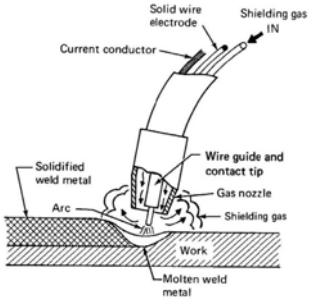
Much of nuclear engineering analysis is concerned with the movement and effects of the neutrally charged forms of radiation, the neutron and the gamma ray. Nuclear engineering includes two subjects not conventionally found in other disciplines:
1. The interaction of radiation with matter, and
2. The time-dependence of the neutron chain reaction.

The history of Nuclear Engineering is dominated by astounding instances of accidental misunderstandings as well as remarkable intellectual endeavor. For example, the concept of the neutron chain reaction was formulated by Leo Szilard, a brilliant Hungarian physicist several years before anyone had the slightest understanding of nuclear fission. And the term "fission" was taken from biology rather than physics. Shortly after the discovery of the neutron by James Chadwick in 1932, Szilard was pondering the liberation of neutrons from a particular isotope of beryllium by the (n,2n) reaction. That's shorthand for one neutron interacts with a nuclide and two neutrons come out. In his little thought experiment, Szilard reasoned that one neutron interacting with a particular beryllium nucleus would give rise to two neutrons. That would happen in the first cycle. These two might interact with two beryllium nuclei to result in a total of four neutrons. That would happen in the second cycle. These four would interact with other beryllium nuclei to yield a total of eight neutrons. And so the idea of neutron multiplication was realized.

6. TITLE: WELDING PRODUCTS – BUSINESS CONSIDERATIONS

PROBLEM STATEMENT:
Your are an engineering team from a company that is supplying welding products to a large fabricator. You have been asked by this fabricator to justify why they should have to pay 10% more for your product than that of your competitor; including any costs, design changes, welding process changes, and manufacturing process changes.

BACKGROUND:
The Internet and high-speed communications continues to shape the world in which companies conduct business. Today, companies must operate at the highest levels of productivity and efficiency in order to remain competitive in the global marketplace. Thus, many organizations are looking at their bottom line to trim costs wherever they can. This problem will evaluate the costs associated with the Gas Metal Arc Welding process (GMAW) also called MIG (See Figure 5-1.) in addition to design, process, and manufacturing costs.



XYZ, Inc. has been purchasing products from your company for the past ten years. However, a sluggish economy and the threat of competition have caused the company to evaluate its cost structure because the companies that they supply their products to are demanding a 5% reduction in cost. In response to this, they placed an Internet bid for all of their vendor-supplied products including the welding consumables that your company currently provides. Your competition was 10% lower in cost for similar products. Due to your long-term business relationship, the company has asked for you to lower your price to that of your competitor in order to maintain the business. Unfortunately, you are unable to offer a lower price to your customer. Instead, your company has offered to perform a Guaranteed Cost Reduction (GCR) to keep the business. The GCR states that your company is willing to guarantee XYZ in writing a specified amount of annual savings by using your products equal to or greater than that of the cost of doing business with your company. If the total amount of annualized GCR savings is less than the guaranteed amount, your company will write XYZ a check for the difference. It is a risk-free program for XYZ and it keeps the business with your company.

XYZ has agreed to allow your engineering team access to their facility in order to perform the audit necessary to complete the calculations for the GCR, which will be used to justify why XYZ should keep you as a supplier even though they will be paying more for your product versus that of your competitor.

XYZ, Inc. employs more than 30 fabricators/welders that are responsible for the assembly of various welded parts. For an example of proving your value and higher price to XYZ, you have decided to focus on their highest production products, racks, to perform the GCR on. In particular, you are focusing your attention on the assembly and fabrication of a base assembly because it is used for various final rack assemblies and takes the greatest amount of time in the overall product's assembly. Additionally, it equates to about 75% - 85% of the final product's total welding costs. For this base assembly, they have created a makeshift assembly line in the middle of their plant for the part assembly (See Figure 5-2.). An increase in productivity at this stage results in large potential savings for XYZ.

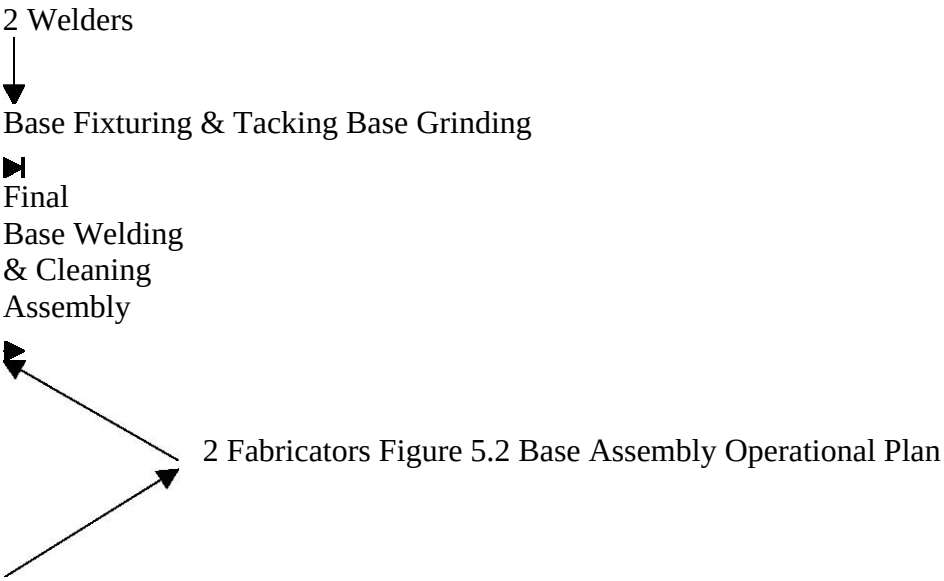


Figure 5.2 Base Assembly Operational Plan

7. TITLE: GREEN DESIGN OF A HIGH SCHOOL

PROBLEM STATEMENT:

A new high school has been designed using the concept of Green Design or Sustainable Architecture. This problem will require your engineering group to look at issues related to designing energy efficient and environmentally friendly buildings.

BACKGROUND:
Green Design incorporates a number of techniques to minimize building energy needs and the impact on the environment. Energy used for transportation, lighting and thermal comfort can be reduced through careful planning, the use of high-energy efficiency components, and the use of renewable energy sources. Water usage and wastewater generation can be reduced by reusing rainwater and reducing ground runoff from paved surfaces. Efforts are made to improve the quality of the air within the building while reducing the quantity of toxic emissions into the atmosphere. Green Design also reduces the quantity of solid waste that must be hauled to a landfill by recycling and reusing building materials whenever possible.

8. TITLE: DISTRIBUTED RENEWABLE ENERGY (DRE) SYSTEM ANALYSIS

PROBLEM STATEMENT :
Your team has been hired to study the feasibility of replacing the current centralized power-plant based electrical power generation and transmission system with a network of small distributed renewable energy systems owned by individual homeowners or local communities.

BACKGROUND:
Fossil fuel based power plants that burn coal and natural gas provide the majority of electrical power used in the world today. However, there are concerns with air pollution, global warming, and rapidly decreasing fuel reserves associated with fossil-fuel power plants. These concerns, coupled with increasing levels of population and energy use have led individuals, communities, nations and the world to investigate alternative energy systems. Distributed energy systems offer many efficiency advantages over the current centralized power plant based system because the "waste energy" used to generate electricity can also be used to heat water or other similar secondary uses. Localized power production also means reduced transmission line losses, capital investments and interest costs, which can be 25% of the cost of a project. And because there are many decentralized power nodes, failure of one system in a Cleveland, Ohio neighborhood won't impact a factory in upstate New York. Such systems make it far harder for terrorists or unscrupulous energy executives to disrupt a region, a state or a nation.

To address the environmental and fuel supply concerns, renewable energy systems utilizing solar and wind energy are the leading alternatives and both have been developed and used successfully on a small scale. The fuel supply and environmental concerns continue to get more serious as world population grows (already greater than 6 billion in 2000) and worldwide electricity demand increases (already 110 million barrels per day oil equivalent (MBDOE) in 2000). Industries and homes in the United States use a disproportionately large amount of energy compared to the worldwide average. An average US household consumes about 26 kilowatt hours (kWh) of electricity per day. Artificial lighting, heating/cooling systems, large appliances and entertainment systems form the majority of the electrical load in most homes, office buildings and retail stores. Conservation measures such as using compact fluorescent bulbs for

lighting, replacing older heating/cooling systems and appliances with energy efficient models, and using energy responsibly can have a large impact on the amount of energy used in an individual household or business.

Energy conservation is a necessary first step in any energy policy, but with industrialization of third world countries increasing, projections for population to double to 12 billion by 2050, and projections for electricity demand to increase over 300% to 450 MBDOE by 2050, it is clear that fossil fuels alone will not be able to meet the future energy demand and some alternative energy system will be necessary.

In a solar power system, panels of photovoltaic cells convert sunlight into direct current (DC) energy. The DC power then has to be converted to AC power by an inverter in order to run most household appliances and systems. The overall energy conversion efficiency (the ratio of energy available in sunlight to energy produced) for actual solar energy systems is rather low (~13%). Additionally, photovoltaic panels only create energy when they are exposed to sufficient light, so solar and wind systems require some type of energy storage system to allow a continuous energy supply. 12 V deep discharge batteries are the most commonly used energy storage system, but with the advent of fuel cells there is also a possibility of using solar-generated electricity to convert water into hydrogen and oxygen (via electrolysis), storing the hydrogen, then converting the hydrogen back into electrical energy as needed using a fuel cell.

9. TITLE: AUDIOTORY FEEDBACK TECHNIQUES IN STUTTERING

PROBLEM STATEMENT:
Stuttering in humans is a communication disorder, which often requires long term speech therapy and can have a high relapse rate after the completion of speech therapy. Technology is often used to assist stutterers in a very short period of time (within a few hours and minimal training) to become fluent and significantly reduce their stuttering during periods that they wear an assistive device. The technological devices are based on the use of various auditory biofeedback techniques such as masking auditory feedback, delayed auditory feedback, frequency shifted auditory feedback or a combination of the above. As an engineering team you are asked to explore the effectiveness of biofeedback rehabilitation techniques on human stuttering.

BACKGROUND:
A wearable prosthetic device employing altered auditory feedback has been suggested as an adjunct or alternative to current stuttering therapy. This device provides stutterers, in addition to their own voice that we all normally hear when speaking, another auditory signal that causes increase to blood flow in specific areas to the brain. Research has shown that stutterers have a neurological deficit in the area that integrates auditory and somatic processing i.e., adult stutterers' brains have an inability to compare what we hear ourselves saying with how we feel our muscles moving. The increase in cerebral blood flow tricks the brain to perceive fluency.

Some users of such devices report 'carry-over' fluency, meaning that their fluency persists for some time after removal of the altered auditory feedback device.
A variety of feedback techniques exist:

- In Sine Wave Masking Auditory Feedback (MAF) a sine wave (tone) near the pitch of the user's voice mimics vocal fold vibrations. It may fool one's brain into thinking that his/her vocal folds are vibrating.
- The Delayed Auditory Feedback (DAF) allows the user to hear his or her own voice with a slight temporal delay, similar to an echo.
- The Frequency-shifted Auditory Feedback (FAF) allows the user to hear his or her own voice with a shift in the pitch, so the signal heard is either at a slightly higher or slightly lower pitch than the person's own voice, typically one-half octave up or down.
- The use of DAF and FAF can significantly enhance fluency levels in a variety of situations including reading, monologue, using the telephone and speaking in front of an audience. The condition of NAF is non-auditory feedback.

10. TITLE: WIRELESS COMMUNICATIONS

PROBLEM STATEMENT:

As a member of the engineering group in a local wireless communications company, you are required to conduct tradeoff studies on the performance of available radio equipment to satisfy the fixed and mobile wireless communications requirements of your customers. This requires you to investigate various aspects of the system performance, from the perspective of both the system operator and the customer.

BACKGROUND:

The company has two radio systems, each of which is capable of offering two different data rates. A subscriber can employ only one data rate at any given time. The first radio system, called the area coverage radio (ACR) uses phase modulation, and offers subscribers data rates of either 2kbps (2000 bits per second) or 8kbps (8,000 bits per second). The second radio, called the spatially adaptive coverage radio (SACR), uses frequency modulation and adaptive antennas, to provide data rates of 16kbps (16,000 bits per second) and 256 kbps (256,000 bits per second). Both radios use a spread spectrum (SS) transmission technique, which allows multiple users to occupy the radio channel simultaneously: the ACR uses direct-sequence (DS) spread spectrum; the SACR uses frequency-hopped (FH) spread spectrum.