

TEAMS 2002 PROBLEM STATEMENTS

The following are the preliminary Problem Statements and the initial Background material for the 2002 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: BREAD MAKING

PROBLEM STATEMENT:

Behold the beauty of the bread baking business. The commercial bread-making process is very technical in order to produce a high quality product with uniform consistency. This problem investigates technical issues related to the typical production of 10,000 loaves per hour of enriched white bread.

BACKGROUND:

The main raw ingredients (i.e., flour and sugar) are delivered by hopper cars and stored in silos at the facility. The ingredients are transferred to a weigh hopper by high velocity air in pneumatic tubing. After the ingredients are weighed, they are mechanically mixed for 4 minutes in 1000 kg batches. This mixing generates so much heat that the mixers must be cooled with an antifreeze solution of propylene glycol. This batch is allowed to ferment in a dump cart for 4 hours at room temperature. This gas-filled “sponge” is mixed with the remaining dough ingredients and allowed to ferment again in a dump cart for 20 minutes of “floor time.” The dough is then divided into uniform volumes by a high pressure piston, shaped into round balls (to create a skin to control moisture content), molded into a loaf shape and dropped into a baking pan. The loaves then enter the proofer for a final raising under closely controlled temperature and humidity. The bread is baked for 20 minutes in a continuous oven. Emissions of Volatile Organic Compounds (VOCs) to the environment during the baking process are a concern to the federal EPA. Upon leaving the oven, the bread must be cooled by conditioned air before being sliced, wrapped and transferred to the warehouse for delivery to your neighborhood supermarket.

2. TITLE: BRIDGE REHABILITATION

PROBLEM STATEMENT:

As a civil engineering group in a small consulting firm, you are responsible for the design and rehabilitation of several bridges throughout the state.

BACKGROUND:

A small, secluded village recently experienced a 500 year flood and one of the main streets out of town had its bridge lifted off its bearings and washed down stream. After an inspection by the county engineer, the abutments for the existing bridge were determined to be reusable. The original bridge was built in 1936 using steel riveted beams. The village wants to modernize the bridge using current specifications and loadings. The village requests that your group determine the most economical steel beam design, determine the required deck thickness, calculate the

reactions at the abutments and prepare a cost estimate for the construction of the new steel beams, paint for the beams and concrete for the deck.

3. TITLE: WIND CHILL FACTOR

PROBLEM STATEMENT:

Your consulting firm has been hired to study the wind chill factor, which accounts for the enhanced feeling of coldness on a cold day due to the blowing of the wind.

BACKGROUND:

The wind chill factor is reported as the temperature that would cause the same sensation of coldness in still air. That is, if the true air temperature is 40°F and the wind is blowing at such a rate as to cause a wind chill factor of 28°F, it means that the combination of the current temperature and wind speed makes it feel like still air at a temperature of 28°F. The outside feels colder when the wind is blowing because the faster the wind, the greater the rate of heat loss from your skin. In turn, the faster the rate of heat loss from your skin, the colder the skin surface. However, regardless of the wind speed, the *direction* of the heat transfer depends only on the sign of the temperature difference. That is, a hotter body will always lose heat to a colder body. For example, if an ice cube were placed outside on a day when the temperature was 40°F and the wind chill factor was 28°F, the ice cube would melt. Even though the air would “feel” like 28°F to a human, it would “feel” even warmer than 40°F to the ice cube—so it would melt faster than if the wind were not blowing. Note that heat transfer is a means of energy exchange. When something is said to lose “heat” it is really losing energy by a process that we term “heat transfer.” Therefore heat has the same units as those of energy.

4. TITLE: EARTHQUAKE PREPARATION

PROBLEM STATEMENT:

Your engineering team has been requested to investigate the impact of a major earthquake near an industrial city with a population of one million.

BACKGROUND:

A magnitude M 7.5 earthquake having a focal depth of 32 kilometers and an epicenter of 24 kilometers from an industrial city of 1 million inhabitants occurred at 3:00 AM local time today. It resulted in economic losses, societal disruption, morbidity, and mortality—the city was declared a "disaster."

5. TITLE: NATURAL GAS

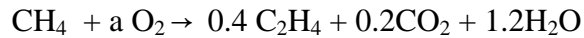
PROBLEM STATEMENT:

Your engineering team has been asked to investigate processes to oxidize the methane and ethane in natural gas in order to produce ethylene.

BACKGROUND:

Natural gas is a mixture of low molecular weight hydrocarbons such as methane, ethane, and traces of other gases. This gas is found underground and is often associated with an oil field.

Your team proposes to partially oxidize the methane and ethane in natural gas according to the following reactions:



(3-1)

[25 % of the methane is converted per pass of the reactor]



(3-2)

[100 % of the ethane is converted per pass of the reactor]

Where coefficients a, b, c, d are to be determined.

6. TITLE: MANUFACTURING

PROBLEM STATEMENT:

Your manufacturing engineering group has been asked to determine a process for the manufacture of a bracket to hold aircraft landing gears. Areas to be considered include: equipment needed, raw materials, factory space and personnel.

BACKGROUND:

The role of manufacturing engineers is critically important to the success of most manufacturing organizations. They are responsible for the successful management of all of the resources, including equipment, tooling, raw materials, factory space, and personnel. All of these resources are valuable, and must be deployed in the most efficient manner.

When a new product is to be produced, a manufacturing engineer decides the best way to produce a component, given the requirements for the part. These requirements include the mechanical properties, the tolerances, surface finish requirements, and the price. During the product design stage, the manufacturing engineers will often work closely with the design engineers to decide on the best manufacturing processes. By teaming with the design engineers early in the part development process, changes can be made to the design, which will be beneficial for all parties involved. For new and existing products, manufacturing engineers select the appropriate equipment, possibly designing custom equipment or ancillary tooling, and may oversee the installation of the new equipment.

The quantity of the products that are required plays an important role in all of the decisions made. For example, components for the automotive industry are often made in quantities of 1,000 to 50,000 pieces per day. With this quantity, it is easier to justify the purchase of expensive automated equipment than it would if only 10 to 100 pieces were required per month.

Once a product goes into production, the manufacturing engineer will continue to work to improve the process. Improvements may be in terms of increasing productivity, reducing cost, or improving the quality of the product. There are many steps in the production of most products, and each of these steps will contribute some variability. A change in one of the processes could significantly contribute to the variability, or the increased variability may be due to the culmination of several smaller variation changes. Whatever the case, the manufacturing engineer is responsible for collecting and analyzing information to determine the cause of the problem. Once the problem is identified, procedures or inspections need to be implemented to rectify the issues or be able to catch the faulty products before they reach the customer.

7. TITLE: NUCLEAR REACTOR ANALYSIS

PROBLEM STATEMENT:

Your engineering group has been assigned to determine several concerns in a nuclear facility. These include the decay and production of ^{56}Mn , and nuclear reactor power concerns and safety.

BACKGROUND:

^{56}Mn decays to the stable isotope ^{56}Fe with a half-life of 2.587 hours. This decay is accompanied by emission of a gamma ray having an energy of approximately 0.85 MeV. Gamma rays are easily detected and their energies are accurately determined using a scintillation crystal connected to a multichannel analyzer circuit.

The equation for radioactive decay is

$$N(t) = N_0 e^{-\lambda(t-t_0)} \quad (7-1)$$

where N_0 is the number of ^{56}Mn atoms at time t_0

$N(t)$ is the number of ^{56}Mn atoms in existence at time t

λ is the radioactive decay constant, calculated from the half-life $T_{1/2}$ by

$$\lambda = \frac{\ln 2}{T_{1/2}} \approx \frac{0.693}{T_{1/2}} \quad (7-2)$$

Since we may choose our reference time for our convenience, we frequently say that t_0 is the zero time and we write

$$N(t) = N_0 e^{-\lambda t} \quad (7-3)$$

Now if we multiply both sides of this equation by the decay constant λ ,

$$\lambda N(t) = \lambda N_0 e^{-\lambda t} \quad (7-4)$$

We use the definition of *activity* $A(t) \equiv \lambda N(t)$ to write the decay equation in terms of activity:

$$A(t) = A_0 e^{-\lambda t} \quad (7-5)$$

where A_0 is the activity at the initial time $t=0$. The units of activity are expressed conventionally as disintegrations per unit time or as atoms disintegrating per unit time. A customary unit of activity is the curie, defined as 3.7×10^{10} disintegrations/sec. The more modern unit is the becquerel, defined as 1 disintegration/sec. The abbreviation for the curie is Ci, while the notation for the becquerel is Bq.

8. TITLE: POWER PLANT SCHEDULING

PROBLEM STATEMENT :

As the engineering group in a local utility, you are required to schedule your three power plants (two coal fueled and one gas fueled) to optimize power generation, and to meet custom demands.

BACKGROUND:

The company has three power plants, two coal-fired plants and a gas-fired combustion turbine. The larger coal-fired plant has a maximum capacity of 800 Megawatts, the smaller coal-fired plant as has a maximum capacity of 400 Megawatts and the gas-fire plant has a maximum capacity of 200 Megawatts.

9. TITLE: GAS TURBINES

PROBLEM STATEMENT:

Your engineering group, working in propulsion systems analysis at Pratt & Whitney, has been asked to respond to questions related to gas turbine technology. A new gas-turbine engine design has been proposed. The design combines a set of engine components that are currently being produced for other engines but have not yet been used together. Your group is tasked with determining how the components will perform when used together, a necessary step before the engine design is seriously considered for production.

BACKGROUND:

Gas turbine engines are used in a wide variety of applications including power plants, boats and helicopters; however, they are most commonly used in jet airplanes. A typical gas turbine configured for use in a jet airplane is comprised of five basic components, shown schematically in Figure 10-1.

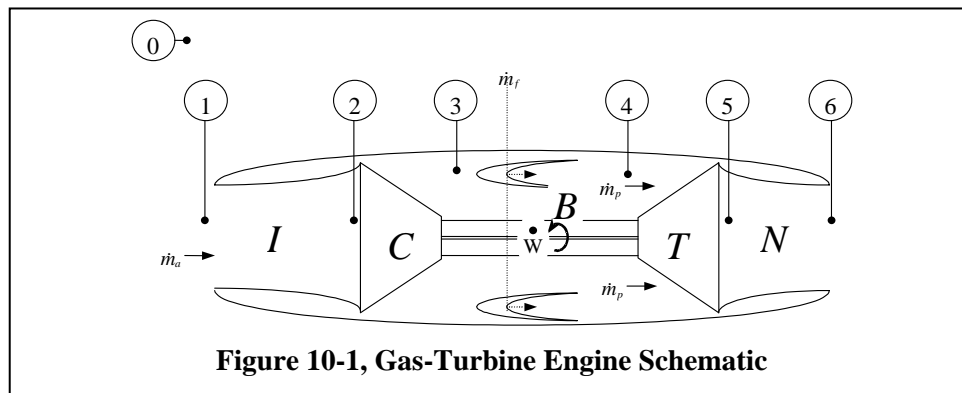


Figure 10-1 shows the five main components of a gas-turbine engine, an inlet (*I*), a compressor (*C*), a burner (*B*), a turbine (*T*) and a nozzle (*N*). Also shown are states designators (0-6), which are in the circles. The states are used to identify the location and properties of the fluid as it moves through the engine. The inlet (*I*) is used to direct airflow into the engine. The air is then compressed by the compressor (*C*) before reacting

with the fuel in the burner (*B*). The combustion products are routed from the burner through the turbine (*T*). The turbine, which is connected by a shaft to the compressor, removes energy from the flow primarily to drive the compressor. Finally, the flow is accelerated through the exhaust nozzle (*N*) to create thrust for the aircraft.

There are several different figures-of-merit used when comparing different gas-turbine engine designs. Some, such as thrust and thrust specific fuel consumption, are analogous to power (i.e., horsepower) and fuel economy (or “gas mileage”) in an automotive engine. There are also some figures-of-merit that are unique to gas-turbine engines such as gross take-off thrust.

10. TITLE: HURRICAN ASSESSMENT

PROBLEM STATEMENT:

Your team has been tasked with: (a) assessing the damage to a building from the impact of a hurricane, (b) recommending a course of action for the repair or replacement of the damaged facility, and (c) recommending specific design/construction alternatives to reduce the potential for damage from future hurricane impacts.

BACKGROUND:

The Sun bathes the Earth with energy, *irradiance*, at an average rate of 1,367 watts per square meter of surface area. This irradiance value must be considered within the context of the 5,100,000,000,000,000 square meters that constitute the Earth's total surface area.

Most of the solar energy is received by the Earth's atmosphere in the tropics, a band of Earth reaching to 23°27' north and south of the equator. As a result it is a lot warmer around the tropics than it is elsewhere on Earth, especially during summer time.

The atmosphere carries out a critical function in continuously trying to balance the extremes of temperature, and associated pressure and moisture that occur, by distributing the energy it receives from the Sun. The atmosphere accomplishes this by moving air, *wind*, from the tropics to the polar regions and by interacting with the oceans, which absorb and store large amounts of heat.

As the accumulation of heat in the tropics reaches extreme proportions the atmosphere often resorts to extreme movements of air, extreme winds known as *tropical cyclones*. Tropical cyclones that hit the United States are called *hurricanes*.