

# 1993 年美国大学生数学建模竞赛 MCM 试题

## 1993 MCM A: Optimal Composting

An environmentally conscious institutional cafeteria is recycling customers' uneaten food into compost by means of microorganisms. Each day, the cafeteria blends the leftover food into a slurry, mixes the slurry with crisp salad wastes from the kitchen and a small amount of shredded newspaper, and feeds the resulting mixture to a culture of fungi and soil bacteria, which digest slurry, greens, and papers into usable compost. The crisp green provide pockets of oxygen for the fungi culture, and the paper absorbs excess humidity. At times, however, the fungi culture is unable or unwilling to digest as much of the leftovers as customers leave; the cafeteria does not blame the chef for the fungi culture's lack of appetite. Also, the cafeteria has received offers for the purchase of large quantities of its compost. Therefore, the cafeteria is investigating ways to increase its production of compost. Since it cannot yet afford to build a new composting facility, the cafeteria seeks methods to accelerate the fungi culture's activity, for instance, by optimizing the fungi culture's environment (currently held at about 120 F and 100% humidity), or by optimizing the composition of the moisture fed to the fungi culture, or both.

Determine whether any relation exists between the proportions of slurry, greens, and paper in the mixture fed to the fungi culture, and the rate at which the fungi culture composts the mixture. If no relation exists, state so. Otherwise, determine what proportions would accelerate the fungi culture's activity. In addition to the technical report following the format prescribed in the contest instructions, provide a one-page nontechnical recommendation for implementation for the cafeteria manager. Table 1 shows the composition of various mixtures in pounds of each ingredient kept in separate bins, and the time that it took the fungi to culture to compost the mixtures, from the date fed to the date completely composted [table omitted].

## 1993 MCM B: Coal-Tipple Operations

The Aspen-Boulder Coal Company runs a loading facility consisting of a large coal tipple. When the coal trains arrive, they are loaded from the tipple. The standard coal train takes 3 hours to load, and the tipple's capacity is 1.5 standard trainloads of coal. Each day, the railroad sends three standard trains to the loading facility, and they arrive at any time between 5 A.M. and 8 P.M. local time. Each of the trains has three engines. If a train arrives and sits idle while waiting to be loaded, the railroad charges a special fee, called a demurrage. The fee is \$5,000 per engine per hour. In addition, a high-capacity train arrives once a week every Thursday between 11 A.M. and 1 P.M. This special train has five engines and holds twice as much coal as a standard train. An empty tipple can be loaded directly from the mine to its capacity in six hours by a single loading crew. This

crew (and its associated equipment) cost \$9,000 per hour. A second crew can be called out to increase the loading rate by conducting an additional tipple-loading operation at the cost of \$12,000 per hour. Because of safety requirements, during tipple loading no trains can be loaded. Whenever train loading is interrupted to load the tipple, demurrage charges are in effect.

The management of the Coal Company has asked you to determine the expected annual costs of this tipple's loading operations. Your analysis should include the following considerations:

1. How often should the second crew be called out?
2. What are the expected monthly demurrage costs?
3. If the standard trains could be scheduled to arrive at precise times, what daily schedule would minimize loading costs? Would a third tipple-loading crew at \$12,000 per hour reduce annual operations costs?
4. Can this tipple support a fourth standard train every day?