

# 1999 年美国大学生数学建模竞赛 MCM、ICM 试题

## 1999 MCM A: Deep Impact

For some time, the National Aeronautics and Space Administration (NASA) has been considering the consequences of a large asteroid impact on the earth.

As part of this effort, your team has been asked to consider the effects of such an impact were the asteroid to land in Antarctica. There are concerns that an impact there could have considerably different consequences than one striking elsewhere on the planet.

You are to assume that an asteroid is on the order of 1000 m in diameter, and that it strikes the Antarctic continent directly at the South Pole.

Your team has been asked to provide an assessment of the impact of such an asteroid. In particular, NASA would like an estimate of the amount and location of likely human casualties from this impact, an estimate of the damage done to the food production regions in the oceans of the southern hemisphere, and an estimate of possible coastal flooding caused by large-scale melting of the Antarctic polar ice sheet.

## 1999 MCM B: Unlawful Assembly

Many public facilities have signs in rooms used for public gatherings which state that it is “unlawful” for the rooms to be occupied by more than a specified number of people. Presumably, this number is based on the speed with which people in the room could be evacuated from the room’s exits in case of an emergency. Similarly, elevators and other facilities often have “maximum capacities” posted.

Develop a mathematical model for deciding what number to post on such a sign as being the “lawful capacity”. As part of your solution discuss criteria, other than public safety in the case of a fire or other emergency, that might govern the number of people considered “unlawful” to occupy the room (or space). Also, for the model that you construct, consider the differences between a room with movable furniture such as a cafeteria (with tables and chairs), a gymnasium, a public swimming pool, and a lecture hall with a pattern of rows and aisles. You may wish to compare and contrast what might be done for a variety of different environments: elevator, lecture hall, swimming pool, cafeteria, or gymnasium. Gatherings such as rock concerts and soccer tournaments may present special conditions.

Apply your model to one or more public facilities at your institution (or neighboring town). Compare your results with the stated capacity, if one is posted. If used, your model is

likely to be challenged by parties with interests in increasing the capacity. Write an article for the local newspaper defending your analysis.

## 1999 ICM: Ground Pollution

### Background

Several practically important but theoretically difficult mathematical problems pertain to the assessment of pollution. One such problem consists in deriving accurate estimates of the location and amount of pollutants seeping inaccessibly underground, and the location of their source, on the basis of very few measurements taken only around, but not necessarily directly in, the suspected polluted region.

### Example

A data set is located at: [procdata.xls](#)

The data set (an Excel file which can be downloaded into most spreadsheets) shows measurements of pollutants in underground water from 10 monitoring wells (MW) from 1990 to 1997. The units are micrograms per liter ( $\mu\text{g/l}$ ). The location and elevation for eight of the wells is known and given below. The first two numbers are the coordinates of the location of the well on a Cartesian grid on a map. The third number is the altitude in feet above Mean Sea Level of the water level in the well.

Well Number (ft)	x-Coordinate (ft)	y-Coordinate (ft)	Elevation (ft)
MW-1	4187. 5	6375. 0	1482. 23
MW-3	9062. 5	4375. 0	1387. 92
MW-7	7625. 0	5812. 5	1400. 19
MW-9	9125. 0	4000. 0	1384. 53
MW-11	9062. 5	5187. 5	1394. 26
MW-12	9062. 5	4562. 5	1388. 94
MW-13	9062. 5	5000. 0	1394. 25
MW-14	4750. 0	2562. 5	1412. 00

The locations and elevations of the other two wells in the data set (MW-27 and MW-33) are not known. In the data set you will also see the letter T, M or B after the well number, indicating the measurements were taken at the Top, Middle, or Bottom of the aquifer in the well. Thus, MW-7B and MW-7M are from the same well, but from the bottom and from the middle. Also, other measurements indicate that water tends to flow toward well MW-9 in this area.

### **Problem One**

Build a mathematical model to determine whether any new pollution has begun during this time period in the area represented by the data set. If so, identify the new pollutants and estimate the location and time of their source.

### **Problem Two**

Before the collection of any data, the question arises whether the intended type of data and model can yield the desired assessment of the location and amount of pollutants. Liquid chemicals may have leaked from one of the storage tanks among many similar tanks in a storage facility built over a homogeneous soil. Because probing under the many large tanks would be prohibitively expensive and dangerous, measuring only near the periphery of the storage facility or on the surface of the terrain seems preferable. Determine what type and number of measurements, taken only outside the boundary or on the surface of the entire storage facility, can be used in a mathematical model to determine whether a leak has occurred, when it occurred, where (from which tank) it occurred, and how much liquid has leaked.