Judge's Commentary: The Outstanding Lawful Capacity Papers

Jerrold R. Griggs
Department of Mathematics
University of South Carolina
Columbia, SC 29208
griggs@math.sc.edu
homepage: http://www.math.sc.edu/~griggs/

Introduction

Judging the Lawful Capacity Problem in this year's contest was an enjoyable experience because of the diverse approaches taken, and the Outstanding papers published here display a truly wide range of modeling approaches. We leave it to the reader to decide which is best!

One nice approach is to use a graphical/network flow model. One paper employs a series of queues to handle the bottlenecks. Another model tiles the room with one-person-sized hexagons and calculates the expected waiting times for each. There is a sophisticated motion simulation model that represents people by disks that naturally flow around obstacles towards exits.

We judges had a tough job selecting the Outstanding papers—one of my favorites didn't get selected! Here are some of the things that we looked for.

Many teams took an overly simplified approach to determine appropriate room capacity restrictions. This basic approach works as follows:

Determine

- an exit flow rate of r people per second per exit,
- the number of exits n in the room, and
- the number of seconds s to clear the room safely,

then obtain a room capacity of rns people.

The UMAP Journal 20 (3) (1999) 331–333.

However, the best papers, including the Outstanding ones published here, allow for a range of significant factors to be included in the model. Among these, they consider the flow of people through the room—not just at the exit—as well as crowd congestion due to bottlenecks created by the room shape and furniture placement. A strong model allows a variable initial distribution of people in the room. Judges were impressed by models that permit people to react to crowding at a nearby exit by switching towards a less crowded, though more distant, exit.

Many entries omit several of the elements requested in the problem; while very few papers manage to cover all of these points, the best ones all come close. These include:

- considering different room arrangements and environments,
- comparing models to posted requirements or codes,
- discussing criteria other than safety, and
- writing an explanatory article suitable for the newspaper.

Researching the problem impressed the judges, such as by consulting existing codes or by gathering data directly from crowd observations. One paper even considers capacity reductions mandated by the Americans with Disabilities Act!

Some papers present easily understood graphs of exit time as a function of the number of people in the room; such displays make it easy for the decision maker.

It was nice to see analysis of model run-time complexity, which is important in dealing with very large or complicated arrangements, along with improvements made by simplifying calculations.

Papers stood out that consider factors that could be included in a more elaborate model, such as crowd panic, accessibility of emergency personnel, ventilation, and crowd flow out of the entire building.

Advice

We conclude by giving advice to future entrants by listing some general tips that the judges feel are applicable to any contest problem.

- *Teams should attempt to address all major issues in the problem.* Projects missing several elements are eliminated quickly.
- *A thorough, informative summary is essential.* Papers that are strong otherwise are often eliminated in early judging rounds due to weak summaries. Don't merely restate the problem in the summary, but indicate how it is being modeled and what was learned from the model. The summary should not be overly technical.

- *Develop a model that people can use!* The model should be easy to follow. While an occasional "snow job" makes it through the judges, we generally abhor a morass of variables and equations that can't be fathomed. Well-chosen examples enhance the readability of a paper. It is best to work the reader through any algorithm that is presented; too often papers include only computer code or pseudocode for an algorithm without sufficient explanation of why and how it works.

- *Supporting information is important.* Figures, tables, and illustrations are very helpful in selling your model. A complete list of references is essential—document where your ideas come from.

About the Author

Jerry Griggs a graduate of Pomona College and MIT, where he earned his Ph.D. in 1977. Since 1981, he has been at the University of South Carolina, where he is Professor of Mathematics and a member of the Industrial Mathematics Institute. He received the 1999 award at the University for research in science and engineering.

His research area is combinatorics and graph theory, both fundamental theory and applications to database security, communications, and biology. He has published more than 60 papers and supervised 11 doctoral and 9 master's students. He serves on the Board of the Mathematics Foundation of America, which oversees the Canada/USA Mathcamp. He has been an MCM judge since 1988.