

**Mathematical Contest in Modeling and Interdisciplinary Contest in Modeling  
Summaries, Pictures and Results  
Simpson College  
2001**

**Choosing a Bicycle Wheel**

by

Lindsay Coffman and Dana Scott  
Honorable Mention

A professional cyclist must choose the most appropriate wheels for a given racecourse. The many styles of wheels offer various weight and aerodynamic combinations. Generally, it is a trade-off. The more aerodynamic wheel will have a greater weight, while the lighter wheel will contribute greater drag. The weight is significant in acceleration and ascending steep terrain, yet the drag of the wheel is crucial at greater speeds.

We compare a spoke rear wheel and a solid disc rear wheel, keeping a constant spoke front wheel. Using general kinematics equations, we develop a strong model to compare the capabilities of the two types of wheels in a variety of situations. The power output of the cyclist is determined by the given cruising speed, considering a flat terrain and the absence of wind. Using this constant output of power by the cyclist and the forces of air resistance, friction, gravity, and wheel drag against the cyclist, we establish a model to calculate the velocity as a function of power, given the wind velocity and grade of the course.

By dividing a racecourse into distances at a given grade, our model definitively determines which of the two wheels will be beneficial to the cyclist. Considering the two cycles on the same course, the model produces the difference in the race times. The model's flexibility allows for application to any racecourse

**Foreign Invaders**

by

Jeffrey Anderson, Brian Depew and Marcy Baker  
Successful Participant

The introduction of zebra mussels (*Dreissena polymorpha*) to North American waterways has caused many environmental and economic problems. The filter feeding mollusks invade lakes and rivers causing disruption to native species by reducing food and habitat availability. The zebra mussel population grows rapidly, making these pests hard if not impossible to control. In our paper we address environmental factors that influence the spread the mussels, a model for their population, chemical effects on the mussels, de-icing agent's effect on long term populations of zebra mussels, and the possibility of introducing round goby fish to control the mussels.

Our model utilizes the idea of a carrying capacity and threshold population level. We also investigated the possibility of using a chaos model to describe the population growth. We analyzed the data using our model to make predictions about the zebra mussels.

We were able to successfully answer the questions regarding the environmental factors that influence the mussels. Using this information we were able to predict whether the additional lakes for which we received data were susceptible to the spread of zebra mussels.

Through additional research we addressed the questions concerning de-icing agents and round goby fish.

## **More Than a Rainy Day; A Hurricane Evacuation Problem**

by

Amy Lowe, Nate Iverson and Clark Potter  
Successful Participant

Hurricane evacuation traffic is sometimes so congested that people are ineffectively evacuated. Many actions can be taken to reduce the congestion of evacuation traffic, but these are often time-consuming, expensive to coordinate and unnecessary. Our problem was to determine under what conditions we should take action to improve evacuation traffic flow. Specifically we worked with South Carolina's evacuation plan. Some of the suggested actions to improve traffic flow are as follows: Direct traffic into opposite lane of highways, effectively making the highways one way evacuation routes; Restrict vehicle types in order to prevent excess congestion; Stagger the evacuation to keep flow stable; Add temporary shelters in key areas to buffer traffic flow.

From our model, we projected the maximum number of evacuating vehicles that only two lanes of I-26 would carry is 144,000, an estimated 312,000 people. Because of this, we would recommend opening both lanes of the highway when it is projected that 300,000 people will evacuate.

Maps 1, 2 and 3 have the evacuation routes of the South Carolina coastal region. We have highlighted possible bottlenecks in pink. Our recommendation is that the output roads be monitored during an evacuation and traffic be reversed on a by need basis.

We did not find any reason to think staggered evacuation would provide a realistic solution to the model. To stagger evacuation fully assumes that people are going to listen to orders from whoever is in charge. We think this is a faulty assumption.

For limitations on vehicle types we found little problem unless the length of the vehicle was longer than 29 feet.

## **Choosing a Bicycle Wheel**

by

Matt Behrens, Brian Mann and Kirstin Ehm  
Successful Participant

Different wheels provide different racing results. We are trying to find how significant these results are and if they have any drawbacks. We are considering two different wheels for the rear of our bike. Specifically, we want to compare spoke wheels to disk wheels. Instead of considering the power differences required for the wheels, we were able to find a website that gave us results for specific time trials. We thought that using this method would give the director sportif information that could be more directly applied. As opposed to figuring out the amount of power that his rider would need to use, we will be able to show him the amount of time that is saved or lost using these particular wheels. We are also going to figure in varying road grades and wind speeds so the information can be applied to many different tracks. We have found that a disk wheel is advantageous when the rider is facing strong headwinds, and when there is little to no road grade. The spoke wheel is beneficial when the road grades are greater and when there are strong lateral winds. We were also able to find that the disk wheel cannot be used when the winds are greater than 15 m/s because it has a negative drag coefficient at this point. We tested our model using the two individual time trials for the 2001 Tour de France, so that the director sportif could have a cutting edge on the competition.