

**Mathematical Contest in Modeling and Interdisciplinary Contest in Modeling
Summaries, Pictures and Results
Simpson College
2003**

Gamma Knife

by

Ashley Bennett, Greg Elliott and Teresa Kreykes
Meritorious

Our first model used the volumes of the spheres and of the general tumor shapes. We used basic three dimensional geometric figures as our target volume of the tumor and examined how to arrange the spheres in order to cover 90% of the tumor volume. The only tumor shapes that would meet the requirements of this model were spherical and almost identically sized to the beam volumes.

We then switched to looking at the spheres and tried to find tumor-shapes that would meet the 90% coverage area requirement. We tested different combinations of 4mm spheres and found that the only tumor shapes that filled 90% of the target volume were almost exactly the same as the spheres, slightly larger than the sphere, or the same shape as multiple-sized spheres combined. Finally, we considered the distance from the sphere that would receive at least 50% radiation using the assumption that radiation occurred outside the sphere.

Stunts

by

Joe Wilson, Nick Damm and Brian Mann
Honorable Mention

We present a hypothetical, yet reasonable calculation of the physics and dimensions involved in determining the number and shape of cardboard boxes necessary to ensure a stunt person is safely cushioned from a given fall. We approach the modeling problem using the kinematics equations and the Law of Conservation of Energy. We also address the ideal box and configuration for a given situation.

In our specific instance, we use a stunt person traveling at 26 m/s, achieving a maximum height of 4 meters, and our ideal box. The number of boxes for our landing area is 288. When we incorporate our protection of the stunt person for a misaligned takeoff of 2 degrees, the number of boxes increases to 1,824.



Nick, Joe and Brian in the computer lab
working on their modeling project.

Gamma Knife

by

Shanie George, Shristi Upreti and Elitsa Banalieva
Successful Participant

Our team, Aleph Consulting, developed a basic model that describes the ideal treatment plan for City Hospital Zoo, for varying size tumors, using a gamma knife on 37 different patients.

First, we put into consideration a number of given constraints. To optimize our model and make it more flexible for a variety of situations and patients, we used a random number generator to produce some of the independent variables to determine our dependent estimate, the Maximum Dose Quantity. We also considered the radius of the tumor and the radius of the beam in order to avoid ray overlapping and exceeding the volume of the tumor so that normal tissue surrounding the tumor is not damaged.

Second, we used the helmets with holes of radii 2, 4, 7 and 9 mm, which correspond to the radii of the beams. In order to overcome all of the constraints, we used Regression Analysis to come up with an equation having five unknown variables. Our generated data and equation accounted for four different cases of hole-radii in order to optimize the treatment Dose:

- A. when $r = 2\text{mm}$
- B. when $r = 4\text{mm}$
- C. when $r = 7\text{ mm}$
- D. when $r = 9\text{mm}$

Thirdly, we created a reasonable equation of best variable combinations to find the dose gradient and the maximum allowed amount of normal tissue destroyed by the radiation.

Fourthly, our analysis incorporated suggestions to use linear programming in 5D to find the ranges of the different variables. Having examined the strengths and weaknesses of our model, Aleph Consulting proposes a unique solution to allow for a wide range of applications under most conditions.

Brain tumors can be treated through the gamma knife procedure. Beams of diameters 4mm, 8mm, 14mm, and 18mm are shot from a helmet to the tumor. Our goal was to find an algorithm that would best arrange the spheres. We want to minimize overlapping of spheres, protrusion of spheres outside of the tumor, and the total number of shots needed. We tested three models to find the most effective one.