STATISTICS

Matti Hautamaeki of Finland competes in the men's ski jumping team event. Ski jumpers know that the fastest path from point A to point B is not always a straight line.

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Want to win a medal? Just do the math

From the ideal curve of a ski jump to scheduling judges to managing lineups, sophisticated calculations are involved

BY ARVIND GUPTA

As the Olympics begin their second week, I am amazed by the efforts of the many thou sands of individuals who are ensuring that the 2010 Games are a success.

I can't help but notice that in just about every aspect of the Games, there's a nugget of mathematics.

And I'm not talking just about the number of medals Canada will win or even how much revenue we'll take in from all the visitors.

I'm also thinking about the sports themselves, the athletes' training, their equipment, venues and the logistics of coordinating such a huge effort.

From the ideal curve of a ski jump to the fastest bobsleigh, from scheduling judges, officials and athletes to managing visitor lineups and to broadcasting, there's sophisticated mathematics involved. Without it, sporting events like the 2010 Winter Games would be totally different (and far less exciting).

Let's start by looking at the ski jump. A ski jumper wants to get down the "in-run" — the ramp — as fast as possible to gain speed.

You've no doubt heard the adage that the quickest route between two points is a straight line, but this turns out to be folklore in this case. In 1696, Sir Isaac Newton (who studied gravity very carefully) and four other mathematicians solved the tongue-twisting Brachistochrone Problem.

They weren't thinking about ski jumps per se, but they found that it is faster for an object to travel down a curve — not in a straight line — so as to maximize the effect of gravity even if it means the object must travel slightly uphill near the end.

But that's not all the math involved in ski jumping.

You'll see ski jumpers crouch on the way down the ramp to minimize friction and then flatten out, open their skis and shape their bodies into wings during the jump. That's an application of Bernouilli's Principle and getting it just right could be the key to a medal.

After launching, jumpers want air to flow faster over their bodies than under their skis, creating an area of low pressure above and high pressure below. This pressure difference creates an upward lift, which keeps the jumpers aloft, similar to a glider.

Coaches and equipment manufacturers know that it's a combination of skill plus mathematics that leads to a winning performance.

Speed skating coaches use image-processing methods to analyse movement, posture and joint angles to improve an athlete's technique. Even tiny changes in the angle formed by skates to the ice will affect speed and will be the difference in attaining a great result.

Bobsleighs and skis are just two pieces of equipment designed using a technique called computational fluid dynamics (CFD). CFD uses numerical methods and algorithms to analyse how gases (like air) and fluids (like water) flow over different shapes and surfaces. This helps designers to shape equipment in such a way that achieves the greatest speed and least friction. The same math is used to design aerodynamic suits and helmets for skiers, lugers, bobsledders and speed skaters.

Now let's turn to the spectators. We all want to minimize the time we spend in Olympic lineups.

Organizers will be using Poisson's Law, a theory that describes probabilities of large-scale, random events to help predict how many people will arrive, when and for which sporting event. This will help them anticipate the number of visitors at each venue per hour, predict peak waiting times and thus ensure appropriate staffing levels to move spectators through security as quickly as possible.

Organizers also will be well-positioned to handle the cheering crowds when (not if) Canada wins hockey gold, using the mathematical theory of discontinuous dynamical systems.

This tool can analyse the movement of tens of thousands of people and help organizers determine where spectators are likely to go following the big win and what route they will take to get there. The Vancouver police department and TransLink will be interested in that information.

Scheduling so many events and venues, not to mention thousands of judges, officials and volunteers, is a colossal task that builds on the work of countless mathematicians. A complex mathematical approach called Operations Research allows for the analysis of large, complex situations and provides the most optimal decision based on various constraints.

In the case of the 2010 Winter Games, constraints could include the maximum duration of a volunteer shift, the distance a judge must travel between events or how long an official must remain at a certain venue.

I'd hate to think of the flurry of activity that a last-minute change to the schedule could impose.

And what about the media? They've been in town setting up their equipment for weeks, preparing to send real-time updates into our living rooms, computers and cellphones. But not without math; the encryption of data and wireless communications have roots in mathematical number theory.

Whether you are an athlete or simply enjoying the 2010 Winter Games doesn't require you to be a mathematician. But you just might impress the person sitting next to you with a nugget of number knowledge before singing our anthem at the medal ceremony.

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Winter Olympics by the numbers

1 What are the odds of a Canadian making it to the Olympic Games?

There is clearly a genetic basis for doing well at sports (height, length of stride, hand-eye coordination, muscle-to-fat ratios, quick-twitch muscles, et cetera are all genetically based) but let's assume that each Canadian has an equal chance of making it to the Winter Olympics. Also, let's assume that you have three Olympics, on average, that you could be selected for.

No. of Canadians: 33.3 million

No. of Canadian athletes: 206

Assume each Canadian has a chance to make it to three Olympics (say when they are 20, 24, and 28). Then the odds of making it are: 1 in 50,000

2 By comparison, what are the odds of an American making it to the Olympic Games?

No. of Americans: 304.1M

No. of American athletes: 238

Assume each American has a chance to make it to three Olympics (say when they are 20, 24, and 28). Then the odds of making it are: 1 in 430,000

3 By comparison, what are the odds of someone from India making it to the Olympics? From China? From Africa?

No. of Indians: 1.14B

No. of Indian athletes: 3

Odds: 1 in 125M

No. of Chinese: 1.33B

No. of Chinese athletes: 91

Odds: 1 in 5M

No. of Africans: 1B

No. of African athletes: 9

Odds: 1 in 37M

4 What are the odds of making the 2010 Canadian Olympic team in the various sports: hockey, alpine, biathlon, bobsleigh, cross-country, curling, figure skating, freestyle, luge, Nordic combined, short track, skeleton, ski jumping, snowboarding, speed skating?

Alpine: 1 in 1.5M

Biathlon: 1 in 4.2M

Bobsleigh: 1 in 2.8M

Cross-country: 1 in 2.2M

Curling: 1 in 3.3M

Figure skating: 1 in 2.8M

Freestyle skiing: 1 in 1.85M

Hockey: 1 in 750,000

Luge: 1 in 3.3M

Nordic: 1 in 33M

Skeleton: 1 in 5.6M

Ski jumping: 1 in 8.3M

Snowboarding: 1 in 1.85M

Speed skating: 1 in 1.3M

5 What were the odds of Canada breaking its gold-medal drought at home?

If every athlete (or team) has an equal chance of winning the gold in their event, then the chances were over 999 in 1,000 that Canada would win a gold medal. (Quebec's Alexandre Bilodeau was the first to accomplish this feat in the men's moguls freestyle skiing event.)

6 What were the odds of Canada failing to win a gold medal?

Assuming the same as in Question 5, it would be less than 1 in 1,000.

Olympic statistics courtesy of MITACS, a national research network for the mathematical sciences. Visit mitacs.ca.