Pure Mathematics 30

Student Project: The Winter Sport of Biathlon

February 2006

Alberta
EDUCATION

Pure Mathematics 30

Project: The Winter Sport of Biathlon

Introduction

In this project, you will be investigating various aspects of the winter sport of biathlon. Biathlon is a Winter Olympic sport that combines cross-country skiing with precision target shooting. Biathlon is unique in that it forces athletes to push themselves to their limit when skiing and then to be calm and focused on the shooting range.

A biathlete is required to ski over a set course carrying his or her rifle before entering the range for the first time. The first time that a biathlete is in the range, he or she assumes a prone (lying down) position and fires five shots at five knockdown targets 50 m downrange. Depending on the race, either a time penalty or penalty laps are assessed for any missed shots. The biathlete then returns to the course and skis another loop. The second time that the biathlete enters the shooting range, he or she fires shots from a standing position. Again penalties are assessed for any missed shots. The biathlete then skis a final loop of the course to complete the race.

The origins of the biathlon can be seen illustrated in rock paintings in Norway, dating from as early as 3000 BC. Modern biathlon started in Norway in 1767 and was part of the first Winter Olympics in Chamonix, France. The event was open only to military athletes. The first biathlon Olympic competitions open to civilian athletes were held in 1960 in Squaw Valley, California. Biathlon is slowly growing in popularity in North America. In Europe, it is one of the most popular winter sports on television.

Part A

The 2002 World Junior Championships in biathlon were held in Ridnaun, Italy. In the Youth Men (16- to 17-year-olds) category, three of the four athletes sent by Canada lived and trained in Alberta.

1. The first race was a sprint. The athletes skied three loops and shot two sets of five targets each. The number of missed targets was recorded, and the results for the 81 competitors are shown below.

Number of Missed Targets	**Frequency**
0	1
1	12
2	13
3	11
4	19
5	8
6	7
7	4
8	3
9	2
10	1

Using the data from the table, find the mean, to the nearest tenth, and the standard deviation, to the nearest hundredth, of the number of missed targets.

2. • Using the data from the table, determine the probability, to the nearest thousandth, of an athlete missing **at least** 7 targets.

• Assuming a binomial distribution where the mean number of misses out of 10 is used for the value of p, determine the probability, to the nearest thousandth, of an athlete missing **at least** 7 targets.

• Compare the two probabilities of an athlete missing **at least** 7 targets.

• Explain why the two methods of finding the probability of missing **at least** 7 targets resulted in similar or non-similar values.

3. In another event at the 2002 World Junior Championships, athletes shot at 20 targets. A particular athlete had a probability of 0.18 of missing a target. Assuming a binomial distribution, what is the probability, to the nearest thousandth, that the athlete hit **exactly** 16 targets?

4. The top three finishers had the following results:

Position	Time (min:sec)	Number of misses
1st	21:25	2
2nd	21:35	0
3rd	21:38	4

For each miss, the athletes had to ski a 150 m penalty lap. It takes approximately 23 s to ski a penalty lap. The extra time taken skiing the penalty laps is included in the recorded times above.

- What place would the third-place finisher have been in if he had missed only 3 targets? Justify your response.

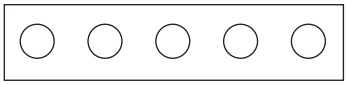
- What advice would you give the second- and third-place finishers in order for them to improve their position in future races? Justify your response.

Part B

An illustration of the 5 targets for two different athletes is shown below. The 5 circles represent the targets that the athletes shoot at. The dark circles indicate missed targets, as shown in the examples below.

1. An athlete can choose to shoot the 5 targets in any order; that is, on his first shot, the athlete can shoot any of 5 targets, on his second shot, he can shoot any of 4 targets, and so on. An athlete does not attempt to repeat the same shot if it is missed. In how many different orders can an athlete shoot at the 5 targets on any given round?

2. The scorekeepers use a blank score sheet, as shown below, to keep track of the missed targets for each competitor by shading in the circle that represents a missed target.



Calculate the number of different possible shadings of this score sheet by a scorekeeper.

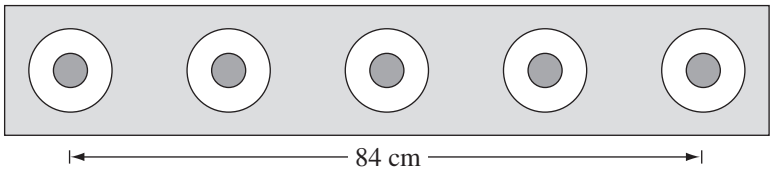
3. At an Alberta Cup race, there are 10 competitors, 3 of whom are members of the national team.

Assume that there are no ties and determine the answer to each of the following questions.

- In how many different orders can the athletes finish the race?
- In how many different orders can the athletes finish the race if the 3 national team members finish first, second, and third?
- The coach needs to select a relay team consisting of 4 athletes for a national competition. If each of the athletes has an equal chance of being chosen, then how many different relay teams of 4 athletes could be selected if the order in which the athletes ski is not important? How many different teams of 4 athletes could be selected if the order in which the athletes ski is important?
- The coach decides that **exactly** 2 of the 3 members of the national team must be on the relay team. How many different relay teams of 4 athletes are possible if the order in which the athletes ski is not important?

Part C

The size of the targets is represented below. The large circle is used when the athlete is shooting from the standing position. It has a diameter of 11.5 cm. The small inner circle, which is slightly larger than a loonie, has a diameter of 4.5 cm, which the athlete must hit from the prone (lying down) position. The targets are 50 m away from the athlete.



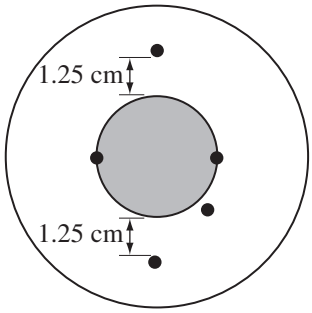
1. If the centre of one of the large circles is at the origin of a coordinate plane, then what is the equation of the large circle in standard form and in general form?

2. If one of the small circles has its centre at the origin of a coordinate plane, then what is the equation of the small circle in standard and general form?

3. The large circle can be considered a transformation of the small circle. Describe the transformation that the small circle would undergo to become the large circle.

4. How many times larger, to the nearest whole number, is the area of a single large circle compared with the area of a single small circle?

5. The pattern of 5 shots on a particular practice target appears to form an ellipse, as shown in the diagram below. What is the equation of this ellipse in standard form? Explain how you obtained your equation.



Part D

1. One of Canada's greatest Olympic athletes is biathlete Myriam Bédard. Write a short biography about this two-time Olympic gold medal winner.

2. Another winter sport that combines separate disciplines is *nordic combined*. Write a short report on the skills involved in this sport and how it is scored.

3. There are other sports (Olympic or otherwise) in which athletes must be skilled in multiple disciplines. Choose one such sport, describe what disciplines are involved in it, and how it is scored. Then, investigate Canadians who are successful at this sport.

4. The Canadian Olympic Committee has set very high standards that athletes must meet in order to qualify for the Olympics. Pick another winter sport and investigate the criteria that must be met in order to qualify for the Olympics in this sport.

The following web sites may help in your research.

www.ibu.at	International Biathlon Union official web page (in English and German)
www.biathlon.ca	Alberta Biathlon web page with links to all types of winter sports
www.biathloncanada.ca	Canadian Biathlon web page (in French and English)

Note: Web site addresses change over time. If the above are not available, then use a search engine and type in key words such as *biathlon* and *Olympics*.