Pure Mathematics 30

Student Project: City Volleyball Leagues

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Alberta Education

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Project: City Volleyball Leagues

Student Task

Volleyball is a team sport played on a special court, and most high schools run both men's and women's teams. In some large cities, schools are organized into divisions, and opposing teams are drawn from schools of approximately the same size. The tasks in this project include the organization of schools into divisions, the use of exponential functions in the forecasting of student enrolments, the use of conic sections in the design of the volleyball court, and the trajectory of the volleyball serve.

Part A

A city has 14 high schools, 10 of which are large schools, and 4 of which are small schools. The volleyball league is arranged into 2 divisions, one for large schools and the other for small schools.

1. Determine the number of regular-season games scheduled in the large-schools division, if each team plays every other team in the division once.

2. Determine the number of regular-season games scheduled in the small-schools division, if each team plays every other team in the division three times.

3. Three teams from the large-schools division and one team from the small-schools division are selected at random to represent the city at a pre-season tournament.

- Determine the number of ways the 4 teams can be selected for the pre-season tournament.

4. The coach at one school estimates that her team has a probability of 0.70 of winning any particular match. Determine the probability, to the nearest hundredth, that her team wins 5 and loses 4 matches in the 9-match schedule.

Part B

In another city, the schools vary in size from 200 to 2 000 students. As a result, the volleyball league is organized into three divisions. The first division is for schools with less than 500 students, the second division is for schools with 500 to 1 000 students, and the third division is for schools with more than 1 000 students.

The table below shows the populations of two schools from 1995 to 2004. School *A* has a population that declined from 1995 to 2004. School *B* has a population that grew from 1995 to 2004.

School Populations Taken in September of Each Year		
Year	**School *A***	**School *B***
1995	1 353	449
1996	1 391	517
1997	1 343	519
1998	1 142	518
1999	1 167	574
2000	1 087	620
2001	999	635
2002	862	605
2003	818	619
2004	755	646

1. Use exponential regression equations of the form $y = ab^t$, where y is the school population and t is the number of years after 1995, to model the populations of School *A* and School *B*. Express a to the nearest whole number and b to the nearest thousandth.

2. Determine, to the nearest tenth of a percent, the average annual rate of increase or decrease for each school.

3. Assuming the same annual rate of decrease, predict the population of School *A* in September 2009. Show the mathematical basis for your prediction.

4. Assuming the same annual rate of increase and using the values of a and b from the regression equation, predict the calendar year in which the population of School *B* reaches 1 000 for the first time. Justify your prediction graphically and algebraically.

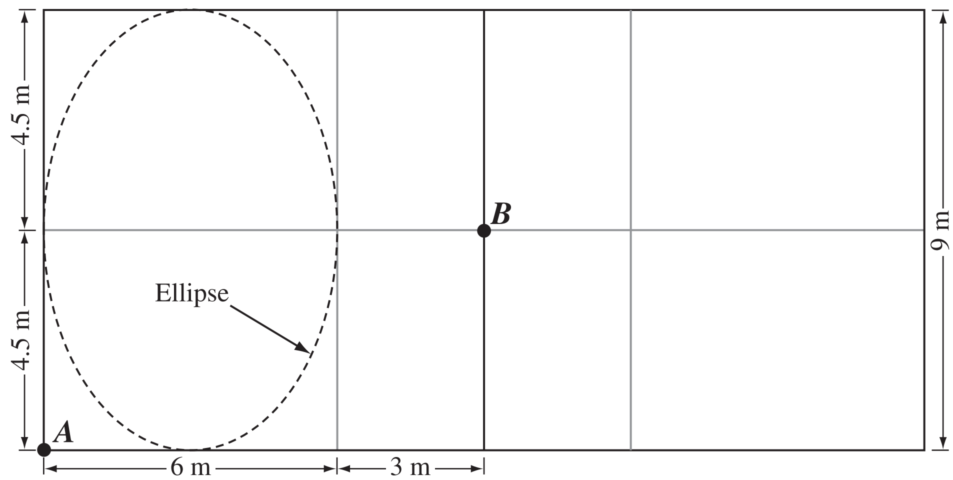
5. Assuming the same annual rates of decrease and increase, predict the calendar years in which Schools *A* and *B* play in the same division of the league. Justify your prediction mathematically.

6.
- Using the same set of axes, sketch the graphs of the regression equations for the populations of School *A* and School *B* as a function of the years after 1995.

- Determine the point of intersection of the two graphs, and explain the significance of the intersection point in the context of this project.

Part C

The dimensions of a volleyball court are shown in the diagram below.

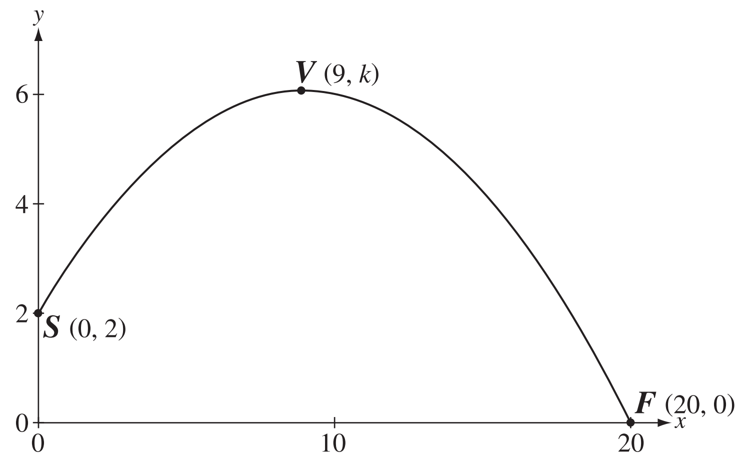


Five of the six players on the receiving team must stand in an approximately elliptical arrangement, as shown in the diagram above.

1. If point *A* is the origin of the coordinate axes, state the standard-form equation for this ellipse.

2. If point *B* is the origin of the coordinate axes, determine the general-form equation for the ellipse.

3. In an overhand serve, the ball starts from a point 2 m above the ground and travels a horizontal distance of 20 m before it strikes the floor. The ball travels in a parabolic path and reaches its highest point after travelling a horizontal distance of 9 m, as shown in the diagram below.



- Determine the equation of this parabola in the form $y - k = a(x - 9)^2$.

Part D

1. Research Canadian university competitions in one sport. Most sports are organized into regional leagues in which each team plays every other team once, and in which there is a regional playoff system and finally a national championship playoff. If a new university joins the competition, determine the effects on the organization of the competition when the new team joins.

2. Research how school boards forecast the populations of various schools in their districts, and describe factors that would change the rate of increase or rate of decrease of a school's population.

3. The parameters of the parabolic paths followed by a volleyball will be different for long serves, short serves, lobs, and spikes. Use any physics text to establish the links between the parameters a, h, and k of the equation $y - k = a(x - h)^2$ of the parabola and the initial speed, v, the initial height above the ground, y_0, and the angle of elevation, θ.

You may wish to use the following websites for information:

Canadian University Sports Organization

www.cisport.ca

Population Forecasting

www.statscan.ca

www.epsb.ca/datafiles/TenYearFacilitiesPlanboard.pdf

Parabolic paths

www.algebraforathletes.com/html/9_1.htm

www.tsn.ca/shows/citc/feature/?fid=1132&hubname=

www.entertainment.howstuffworks.com/physics-of-football1.htm

Note: Website addresses sometimes change. If the websites listed above are not available, use a search engine and type in keywords such as those listed below:

"Canadian university sports"

"demographic trends"

"parabolic paths in sports"