

MfA

$$4 \sum_{k=1}^n \frac{(-1)^{k-1}}{2k-1}$$

Math for America

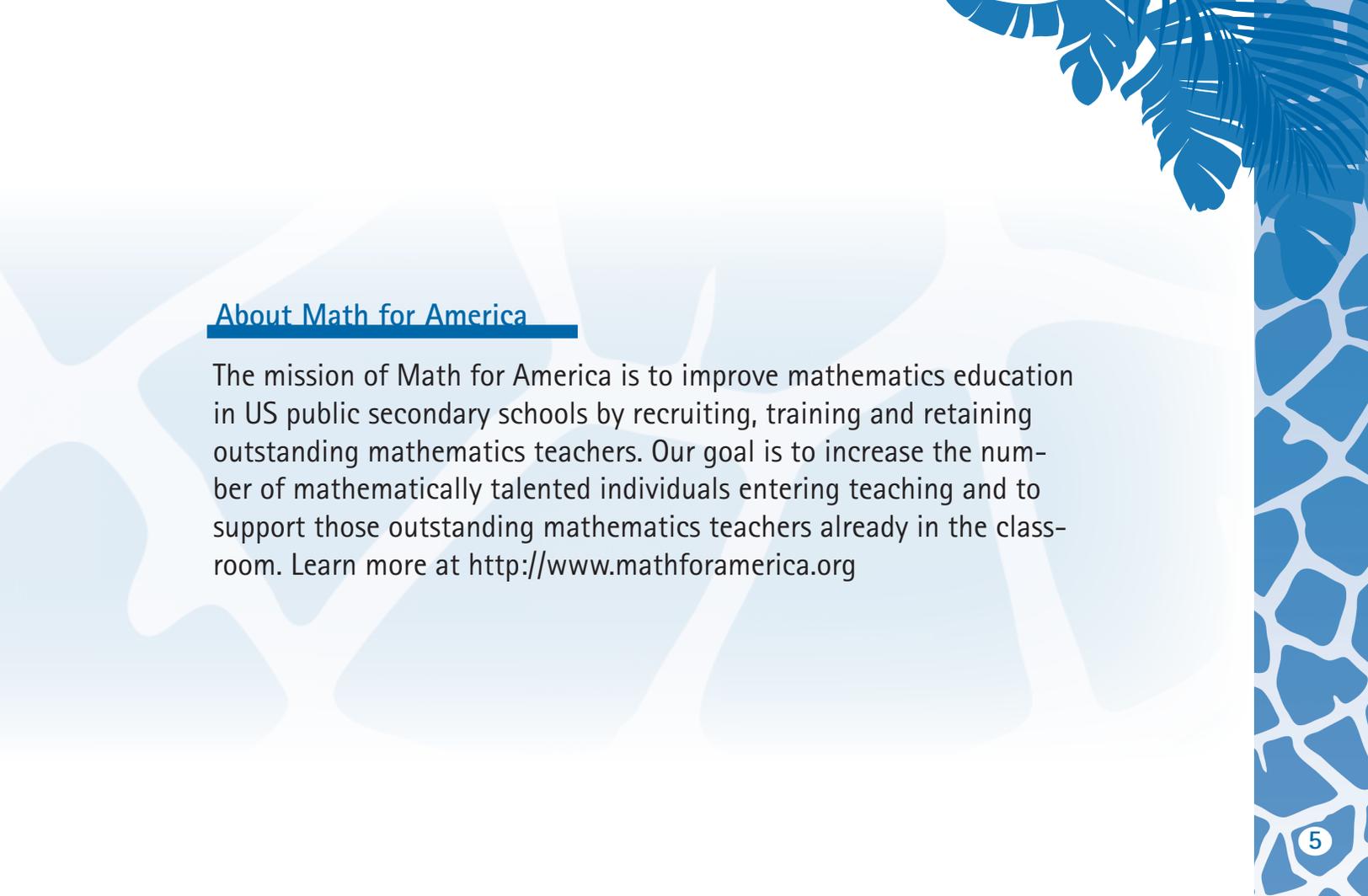


A Math Trail at the Bronx Zoo









About Math for America

The mission of Math for America is to improve mathematics education in US public secondary schools by recruiting, training and retaining outstanding mathematics teachers. Our goal is to increase the number of mathematically talented individuals entering teaching and to support those outstanding mathematics teachers already in the classroom. Learn more at <http://www.mathforamerica.org>



Welcome

to the Math for America Math Trail at The Bronx Zoo.

This Math Trail was created by Ron Lancaster. Ron Lancaster taught middle and high school mathematics for over 20 years and has worked as an independent mathematics consultant for schools, educational organizations and technology companies in North America, Asia and Israel. He is currently a Lecturer in Mathematics Education at the Ontario Institute for Studies in Education of the University of Toronto. Ron is well known for his expertise in designing Math Trails and has conducted numerous workshops for teachers on this topic.



The Trail

Before setting out the Trail, it is suggested that you visit <http://www.bronxzoo.com> for hours of operation, directions and maps.

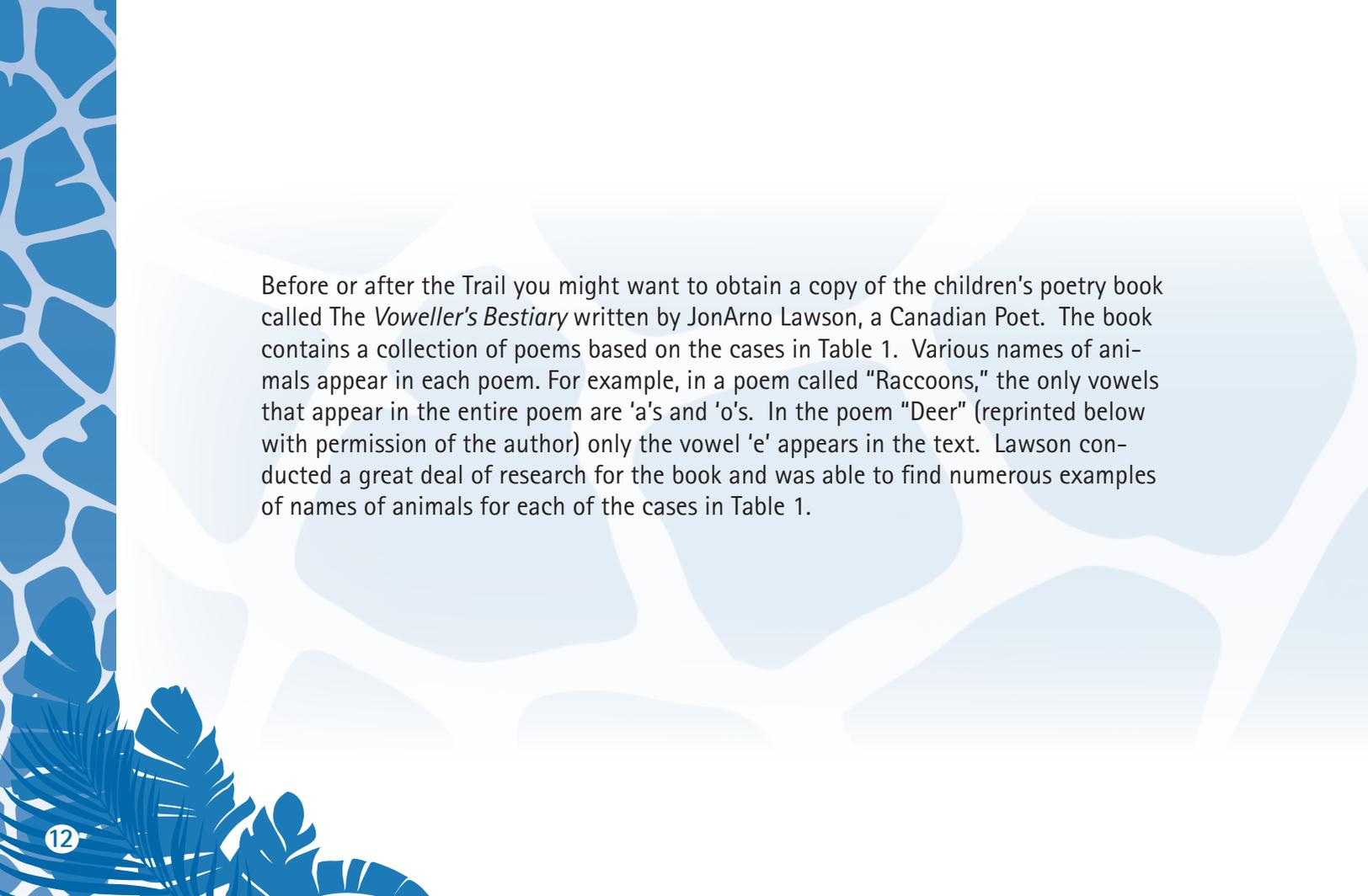
The Math Trail will begin at the Southern Boulevard Gate. Walk into the Zoo past the gate where tickets are purchased and gather in the nearby area.

Question 1

During your visit to the Zoo you will see names of animals everywhere. For example one of the names you will see is anaconda. This name contains two different vowels, an 'a' and an 'o'. As you visit the various exhibits find at least one example of the name of an animal for each of the following cases in Table 1. It is not a problem if a particular vowel appears more than once in the name as was the case for the name anaconda where the 'a' appears three times. The order that the vowels appear within the word also doesn't matter.

Table 1

Vowels used in the name of the animal	Name of animal
a	
e	
i	
o	
u	
a, e	
a, i	
a, o	anaconda
a, u	
e, i	
e, o	
e, u	
i, o	
i, u	
o, u	
a, e, i	
a, e, o	
a, e, u	
a, i, o	
a, i, u	
a, o, u	
e, i, o	
e, i, u	
e, o, u	
i, o, u	
a, e, i, o	
a, e, i, u	
a, e, o, u	
a, i, o, u	
e, i, o, u	
a, e, i, o, u	
none	



Before or after the Trail you might want to obtain a copy of the children's poetry book called *The Voweller's Bestiary* written by JonArno Lawson, a Canadian Poet. The book contains a collection of poems based on the cases in Table 1. Various names of animals appear in each poem. For example, in a poem called "Raccoons," the only vowels that appear in the entire poem are 'a's and 'o's. In the poem "Deer" (reprinted below with permission of the author) only the vowel 'e' appears in the text. Lawson conducted a great deal of research for the book and was able to find numerous examples of names of animals for each of the cases in Table 1.

Deer

Deer delve deeper,
peer between endless greens,
gentle breezes tremble the reeds,
tempers seethe,
regrets deepen.

Whenever we freeze,
then flee -
Whenever we're tender,
then severe -

we resemble deer.

A Voweller's Bestiary: From aardvark to guineafowl (and H)
JonArno Lawson
Published by The Porcupine's Quill
ISBN 978-0-88984-300-4

Question 2

- (a) There are 32 combinations in Table 1. There are also 5 vowels and $32 = 2^5$. Is this a coincidence? Why or why not? If the English language had 6 vowels, would Table 1 have 64 (or 2^6) cases?
- (b) By counting the cases involved, decide which of the following statements are true.
- (i) The number of cases in Table 1 for which 1 vowel is present is equal to the number of cases for which 4 vowels are present.
- (ii) The number of cases in Table 1 for which 2 vowels are present is equal to the number of cases for which 3 vowels are present.
- (iii) The number of cases in Table 1 for which 5 vowels are present is equal to the number of cases for which no vowels are present.
- (iv) The number of cases in Table 1 for which x vowels are present is equal to the number of cases for which $5 - x$ vowels are present.

Question 3

Look straight up the tall tower near the entrance to the Zoo and locate the anemometer (see the information provided below) at the top of the tower. Suppose that the anemometer at the zoo has a digital counter that keeps track of how many times the cups go through a complete turn in a minute. Develop a plan for how you can calculate the speed of the wind from the number of turns.

Cup anemometers

A simple type of anemometer is the cup anemometer, invented (1846) by Dr. John Thomas Romney Robinson, of Armagh Observatory. It consisted of four hemispherical cups each mounted on one end of four horizontal arms, which in turn were mounted at equal angles to each other on a vertical shaft. The air flow past the cups in any horizontal direction turned the cups in a manner that was proportional to the wind speed. Therefore, counting the turns of the cups over a set time period produced the average wind speed for a wide range of speeds. On an anemometer with four cups it is easy to see that since the cups are arranged symmetrically on the end of the arms, the wind always has the hollow of one cup presented to it and is blowing on the back of the cup on the opposite end of the cross.

Source: <http://en.wikipedia.org/wiki/Anemometer>

Question 4

Figure 1 shows a different type of anemometer that you can make after the Trail. You will need a protractor, a ping pong ball and a piece of thread or fishing line. Instructions can be found at:
<http://www.rcn27.dial.pipex.com/cloudsrus/protanemom.html>

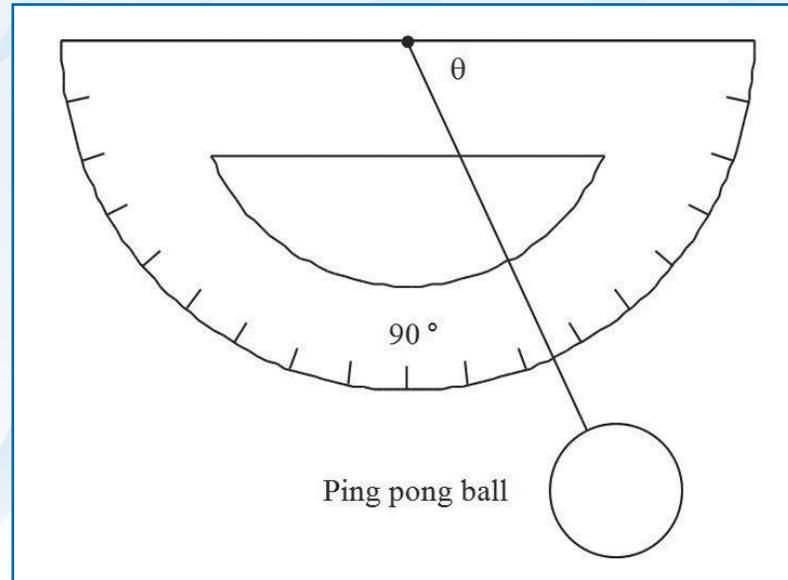


Figure 1

Figure 1

The speed of the wind is determined by measuring the angle θ and then using the data in Table 2 to look up the speed (denoted by s).

- (a) When the angle θ is equal to 90° the speed of the wind is 0 miles per hour. Does this make sense to you? Why or why not?
- (b) When the angle θ decreases in value from 90° to 20° , the wind speed increases from 0 miles per hour to 32.4 miles per hour. Why does the wind speed go up in value and not down?
- (c) Graph the wind speed versus the angle. What type of graph is this?
- (d) Find the line of best fit for the graph of s versus θ . Use the equation to predict the wind speed when
 - (i) $\theta = 10^\circ$
 - (ii) $\theta = 100^\circ$

angle θ	wind speed s (miles per hour)
90°	0
85°	5.5
80°	8.2
75°	10.1
70°	11.8
65°	13.4
60°	14.9
55°	16.4
50°	18.6
45°	19.5
40°	21.3
35°	23.4
30°	25.7
25°	28.8
20°	32.4

Source http://www.uwsp.edu/cnr/wcee/keep/nr735/Unit_3/WhereTheWindBlows_Activity.htm

Question 5

Walk a short distance to the location where people line up for the Zoo Shuttle.

- (a) Estimate the number of people who can line up in the fenced-off area.
- (b) Suppose that the management of the Zoo found that people were waiting too long to board the shuttle. Suggest several ideas for cutting down on the waiting time.

Question 6

The Zoo Shuttle operates from the beginning of April through to the end of October. It does not run on Wednesdays in July and August.

- (a) Without doing any calculations, decide by simply estimating, which of the following is closest to the percentage of days in 2011 that the shuttle is in operation?

30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%

- (b) Calculate the percentage of days the shuttle is in operation and compare the result with your estimate.

Question 7

Follow the signs to the Bronx Zoo Store. Along the way locate and stop at the First Aid building. It will be on your left side, just before the store building. If you get close to the concession stand ahead of you, you've gone too far.

- (a) Which of the following cases (Figures 2-5) best describes the area of the white region relative to the area of the red in the design?



Figure 2



Figure 3



Figure 4



Figure 5

b) Assume that the shaded shape that surrounds the cross is a square. Let the length of the four outer sides of the shaded region be 5 units and let x represent the length of each of the sides of the white cross (Figure 6). Find the value of x for which the area of the white region is equal to

- (i) the area of the shaded region.
- (ii) half of the area of the shaded region.

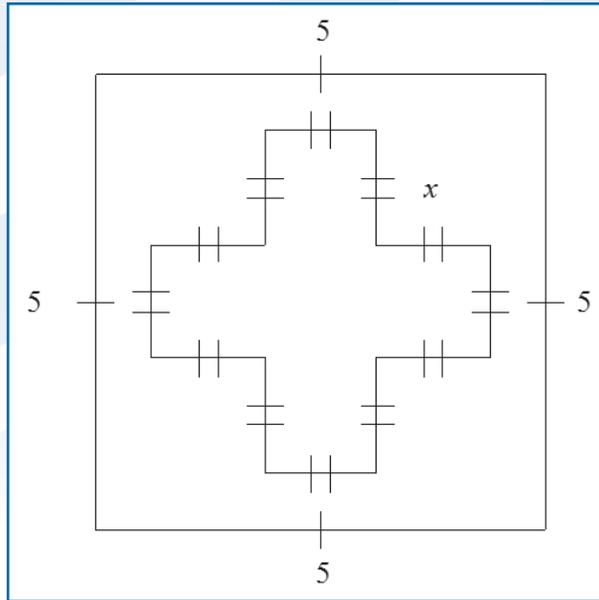


Figure 6

Question 8

Continue to walk to the Bronx Zoo Store. In front of the store locate the machine that flattens a penny into a very thin oval shape (Photograph 1).



Photograph 1

- What is the actual cost of obtaining the flattened penny? Is it 50 or 51 cents?
- If an average of 20 people used the machine for every hour the zoo is open, how much money would be in the machine at the end of the day? How much would the quarters weigh?
- Sit down in the area of the machine at one of the nearby tables and count the number of people who use the machine in a five minute period. Based on the number you have, would you say the figure of 20 stated in part (b) is high, low or about right?

(d) Four different designs are available for the flattened penny and the machine allows customers to choose their own design. Suppose you purchased two flattened pennies and picked your designs at random. What is the probability that the designs would be

(i) the same?

(ii) different?

(e) Turn the wheel several times (you can do this without having to pay 51 cents). How many turns does the wheel with the four designs on it make when the handle is turned through one complete revolution? What other information could you use to answer this question?

(f) The area of a circle is πr^2 . Another way of writing this formula is $\pi \times r \times r$. Use this other way of writing the formula to suggest a possible formula for the area of an oval (Figure 7).

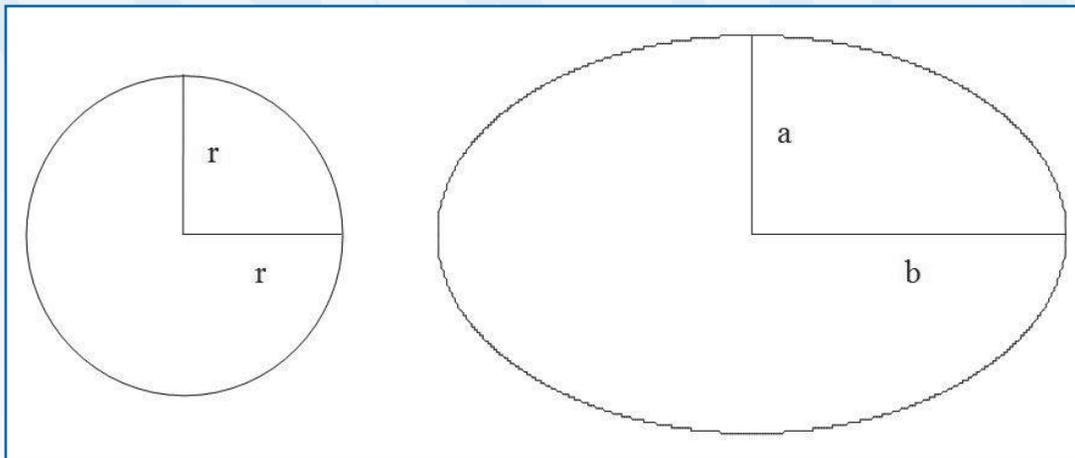


Figure 7

Question 9

In the area near the Bronx Zoo Store, locate an octagonal table with an umbrella (Photograph 2).

- (a) Determine if the umbrella is large enough to completely cover four people sitting at the table during a storm when the rain is coming straight down.
- (b) If all dimensions of the top of the table and the seats were to be doubled, could twice as many people be able to sit at the table? Would the area of the top of the table be twice as large?



Photograph 2

Question 10

Walk to the Bug Carousel, go to the right of the ticket booth, and stop in the area where people can stand and watch the carousel go around.

(a) Study the carousel and verify the details given below.

Carousel Details:

18 Section – 4 Row Carousel

64 Figures

2 Chariots (1 ADA/Wheelchair Accessible Chariot with Companion Seat)

Source: <http://www.carouselworks.com/carPages/bronx.htm>

- (b) Time how long the ride takes from the start to the end. Count the number of times that the carousel goes around over the course of a complete ride. Record your results in Table 3.

Table 3	
time taken for a full ride	
number of times the carousel goes around	

- (c) How long does it take for the carousel to go around once?

Question 11

Find an error in the text provided below.

Patrons of the Bronx Zoo can ride the Bug Carousel for \$2.00 per ride and the carousel is also part of the zoo's Pay-One-Price (POP) ticket value. The Bug Carousel at the Bronx Zoo has been a very lucrative addition to the zoo; approximately 27% of their zoo's approximately \$2,000,000 annual visitors are riding the carousel.

Source: <http://www.carouselworks.com/carPages/bronx.htm>

Question 12

Watch a friend go for a ride on one of the 64 figures (insects) of the Bug Carousel.

- (a) How does the distance (denoted by d) between your friend's feet and the platform directly below him or her change during the carousel ride?
- (b) Graph the distance d versus the time t . Since you have no actual data to work with, a precise graph is not required.

Question 13

Watch a friend go for a ride on one of the two chariots (one is a butterfly bench and the other is a beetle chair).

- How does the distance (denoted by d) between your friend's feet and your feet change during the carousel ride? See Figure 8 for a view from above.
- Graph the distance d versus the time t . Since you have no actual data to work with, a precise graph is not required.

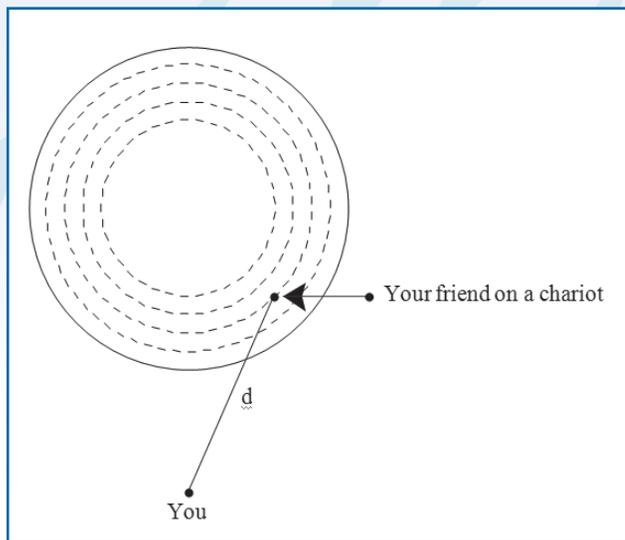
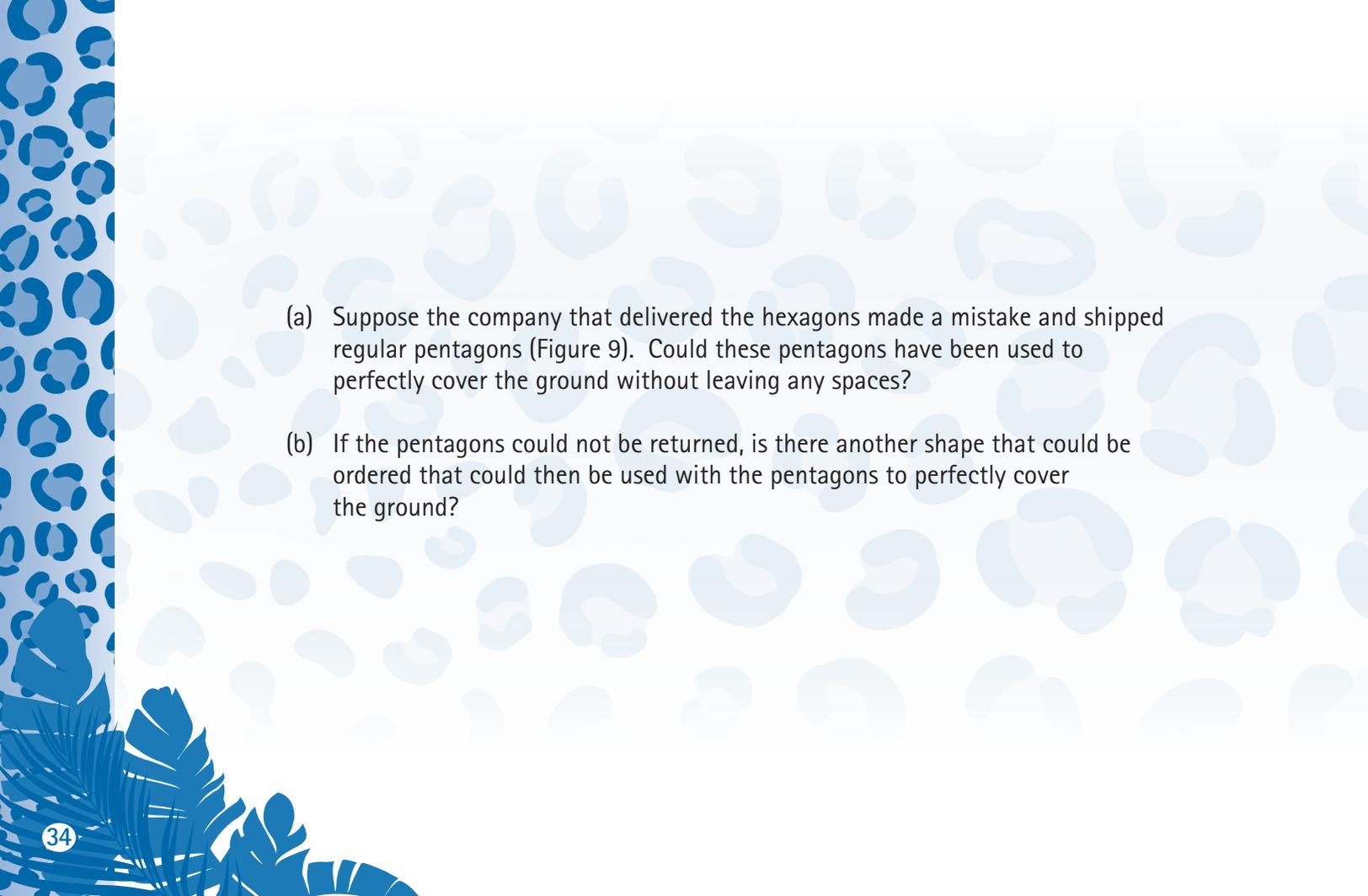


Figure 8

Question 14

Enjoy a ride on the Bug Carousel and then return to the area in front of the Bronx Zoo Store.

The ground below you is covered by hundreds of identical regular hexagons. The hexagons all fit together perfectly without leaving any spaces between them. The arrangement of the hexagons is called a tessellation.

- 
- (a) Suppose the company that delivered the hexagons made a mistake and shipped regular pentagons (Figure 9). Could these pentagons have been used to perfectly cover the ground without leaving any spaces?
 - (b) If the pentagons could not be returned, is there another shape that could be ordered that could then be used with the pentagons to perfectly cover the ground?

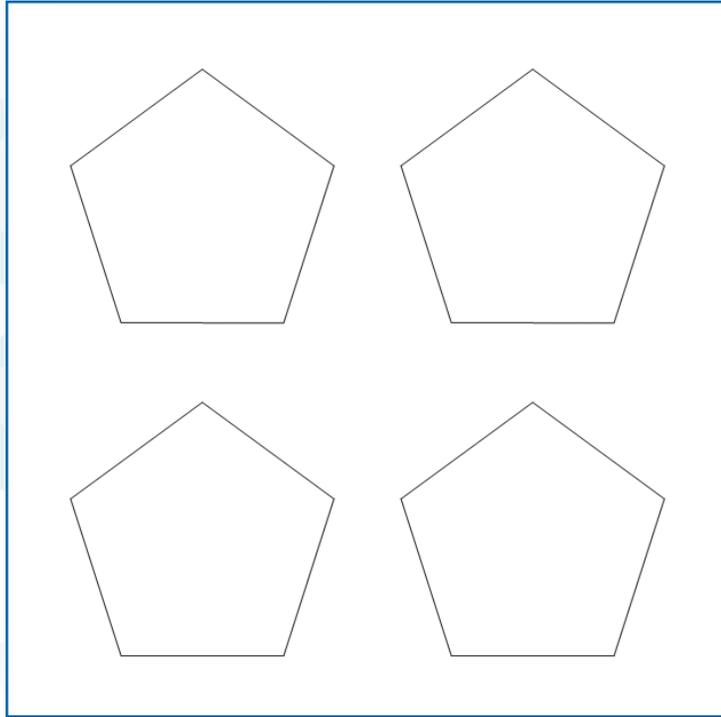


Figure 9

Question 15

Walk to the Zoo Center. When you are a short distance from the building, look for a sculpture of a rhinoceros on your left or right side (Photograph 3).

As you look at the sculpture, facing the rhinoceros' side, you will find three posts with ropes between them that, along with other posts and ropes, are there to keep people from climbing on to the rhinoceros. A possible arrangement of the three posts is shown in Figure 10. What you see will depend on how the posts have been moved by a person who cleans the area (or someone who has been here to do the following activity).

Let x be the height of point A (the lowest point on the rope to the left) and let y be the height of point B (the lowest point on the rope to the right).

- (a) If you were to move Post 2 one foot to the right, what would happen to the values of x and y ?
- (b) Suppose you were to slide Post 2 to the right until it could not be moved any further without tipping over Post 1. Sketch the graph of y versus x . Since you have no actual data to work with (unless you actually move the post and measure the values of x and y), a precise graph is not required.

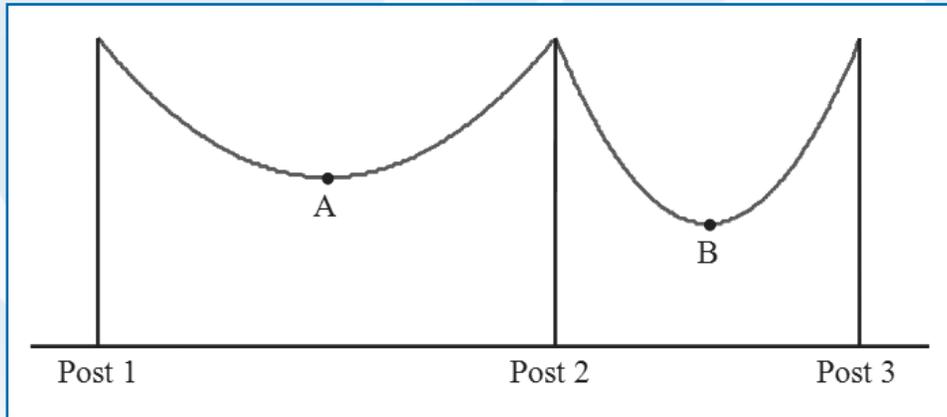


Figure 10



Photograph 3

Question 16

- (a) Read the text provided below. If the population of rhinoceroses continues to decrease at this rate, how many rhinoceroses will there be in 2012?
- (b) If the population of a species is decreasing at the rate of $r\%$ per year, find the value of r for which half the population will be left after three years.

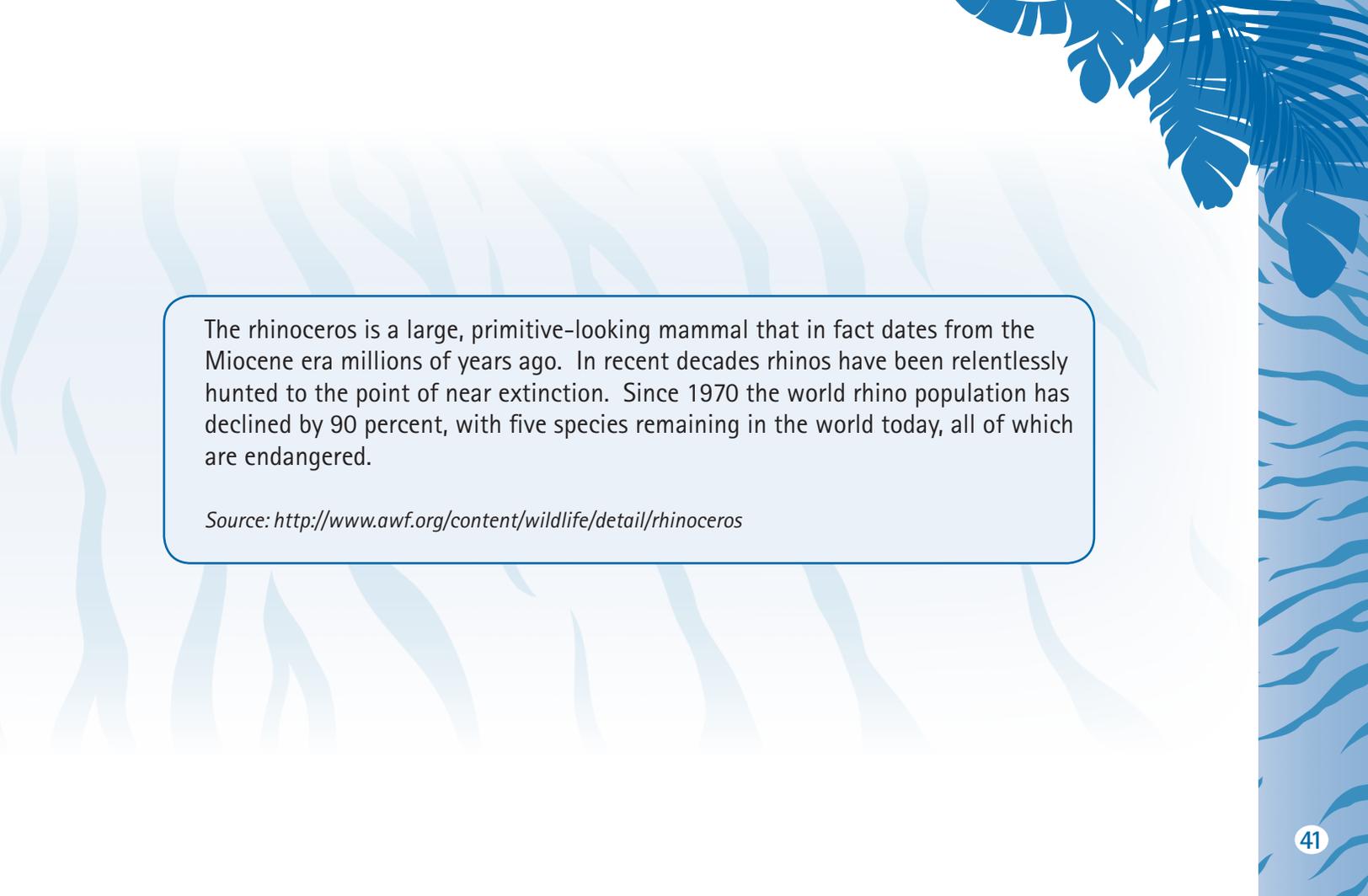
Rhino Population Halved over Past Three Years

New Delhi: The number of rhinoceroses in India is dwindling fast. In the past three years alone, 50 percent of the country's rhino population has gone down, either to man-animal conflicts or poaching. Statistics made available to parliament by the environment and forest ministry show that the country has 2,200 fewer rhinos than it did in 2006. India, which is home to the one-horned rhinos, found only in the subcontinent, has 2,201 of the animals right now.

Source: <http://www.rhinos-irf.org/en/art/649/>

Question 17

- (a) Read the text on the following page. The decrease in the population of rhinoceroses during this 39 year period is truly frightening. If the population of rhinoceroses continues to decrease at this rate, how many rhinoceroses will there be after another 39 years?
- (b) If the population of a species decreases by 90% over a certain period of time, then goes back up by 90% during the same time period, will the population be back to where it was before 90% drop?



The rhinoceros is a large, primitive-looking mammal that in fact dates from the Miocene era millions of years ago. In recent decades rhinos have been relentlessly hunted to the point of near extinction. Since 1970 the world rhino population has declined by 90 percent, with five species remaining in the world today, all of which are endangered.

Source: <http://www.awf.org/content/wildlife/detail/rhinoceros>

Question 18

Where should the animal name rhinoceros be put in Table 1 of Question 1?

Question 19

- (a) Identify the shapes in Figure 11.
- (b) Figure 11 is the start of a drawing of a rhinoceros. Try to finish the drawing! If you are not able to do so, or you need a hint for what to do next, go to <http://www.how-to-draw-cartoons-online.com/how-to-draw-a-rhinoceros.html>

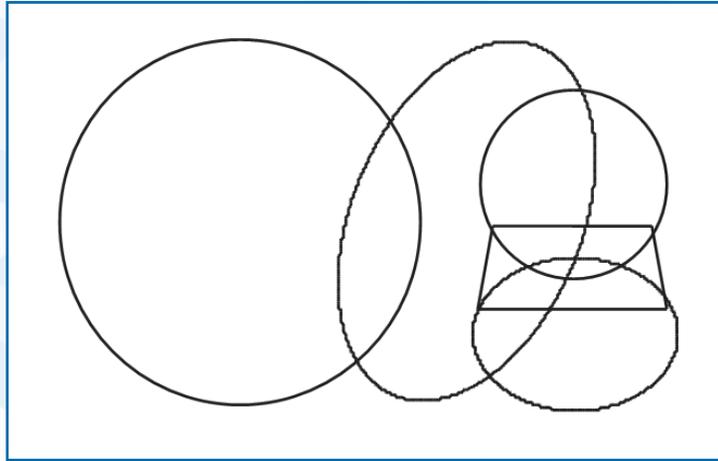


Figure 11

Question 20

Enter the Zoo Center. Look up at the ceiling and locate part of the design that resembles that shown in Figure 12.

- (a) Count the number of bricks in the inner and outer rings.
- (b) Between the inner and outer rings, there is room for five additional rings (Figure 13). Use the numbers from part (a) to calculate the number of bricks that would be contained in each of these rings.

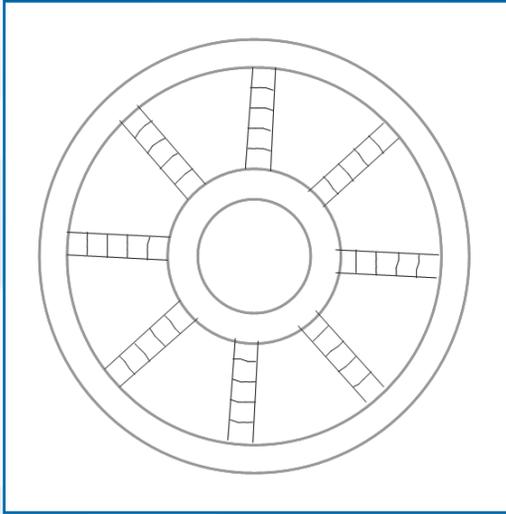


Figure 12

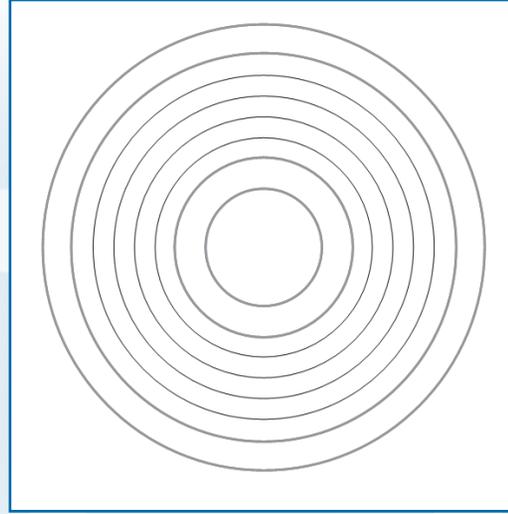


Figure 13

Question 21

Leave the Zoo Center through the doors on the opposite side from where you entered. This area of the Zoo is known as Astor's Court and it contains some of the most beautiful buildings in New York City (see the information provided below).

The Bronx Zoo's image in the public mind now is largely primeval. Visitors best remember glimpsing exotic herds and flocks nestled into simulated savannahs, Himalayan plateaus or rainforests – any architecture onsite pales by comparison. But one of the city's most cohesive Beaux-Arts complexes, on par with Columbia University's campus, lies little known at the heart of the zoo's 265 acres. Called Astor Court, the Neoclassical ensemble contains half a dozen circa-1900 structures plus balustrades, boxwood beds, grottoes and a sea-lion pool. The master plan and most of the buildings were designed by Heins & La Farge, a firm best known for colorfully tiled subway stations. The court's façades are a study in varied peachy-orange shades of Roman brick and stone or terra-cotta animals. The species portrayed – including reptiles, monkeys, pachyderms and big cats – once lived in cages along the court, and millions of visitors annually strolled the balustraded paths.

Source: <http://www.traditional-building.com/Previous-Issues-08/AprilProject08Bronx.html>

- (a) One acre is equal to 43,560 square feet. Which of the following rectangles are one acre in size?

	length (feet)	width (feet)
a	66	660
b	33	1,320
c	22	1,980
d	11	3,960
e	0.66	6,600
f	132	330
g	264	165

- (b) Given that 1 square mile (5,280 feet by 5,280 feet) is equal to 640 acres, what is the size of the zoo in square mile units?

Question 22

Walk to the nearby building called the Madagascar that contains the Madagascar Exhibit. When you walk inside spend a few minutes studying the stunning mosaics on the wall (see the photograph on page 8 of this Math Trail).

Walk through the exhibit and while you enjoy your visit search for names of animals that you can add to Table 1 in Question 1.

Question 23

- (a) Leave the Lion House and walk to the Sea Lion Pool. While you enjoy watching the sea lions being fed, estimate the number of people that can stand in front of the fence that surrounds the circular pool.
- (b) If the radius of the pool area were twice as large, what effect would this have on the number of people who could stand around the circumference of the pool to watch the sea lions? Would the area of the pool be twice as large?

Question 24

Use the information given below to estimate the weight of an adult California sea lion.

Based on records of animals at Sea World, adult California sea lions eat about 5% to 8% of their body weight per day (6.8-18.2 kg or 15-40 lb.)

Source: <http://www.seaworld.org/animal-info/info-books/california-sea-lion/diet.htm>

Question 25

Continue past the sea lions straight ahead toward the Fordham Parking area. Just past the Administrative Buildings on your left and right sides, stop at the area that overlooks the parking area. From where you are standing you should be able to see a beautiful fountain in the center of the area that is surrounded by parking spots.

- (a) Which of the diagrams in Figure 14 provides the most accurate total of the number of parking spaces in the lot?
- (b) Walk down the stairs that lead to the lot and then do one complete walk - carefully! - around the fountain. Count the number of actual parking spots that surround the fountain and compare your count to the estimate you made in part (a).
- (c) If the cars parked parallel to the curb around the fountain instead of sticking out at angle, would more cars be able to park in the lot?

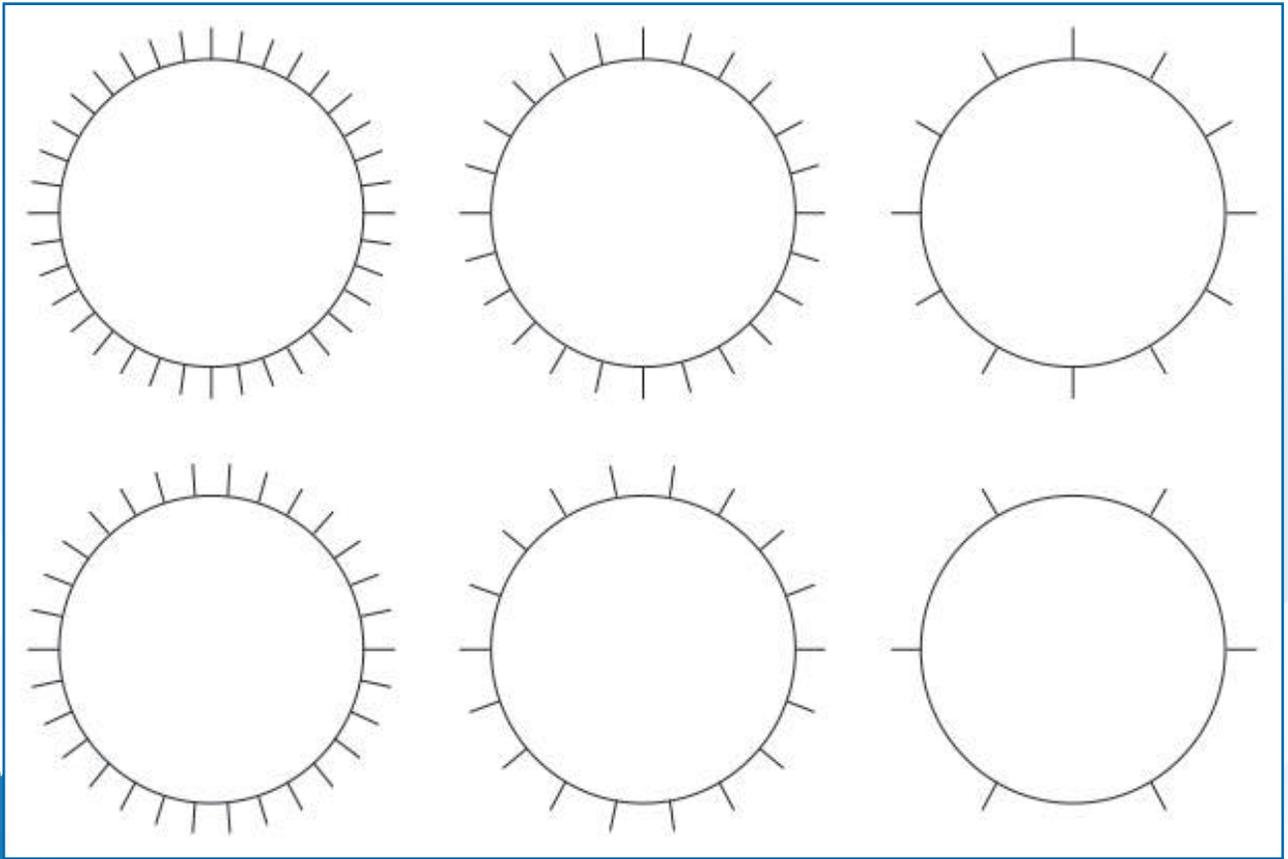


Figure 14

Question 26

In the addition puzzle given below ($GO + TO + THE + ZOO + TO + DO + MATH = TODAY$), each letter represents a digit from 0 to 9. Any given letter stands for just one digit (in other words the value of T cannot be say 3 and 9 at the same time) and two different letters cannot stand for the same digit (so E and N can't both be say 7). Also the first letter of any word cannot be 0. There are four solutions to this puzzle. Good luck finding them!

$$\begin{array}{rcccc} & & & G & O \\ & & & T & O \\ & & T & H & E \\ & & Z & O & O \\ & & & T & O \\ & & & D & O \\ & M & A & T & H \\ \hline T & O & D & A & Y \end{array}$$

This marks the end of the Trail. Before you leave, walk back up the stairs and spend a few moments studying the stunning design of the entire area. If you look on the walls, the ground and the buildings, you will find numerous lovely curves and shapes. Make up your own math question related to something in the area and give it to one of your classmates to solve. Be sure to visit more animal exhibits!

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Math Trails by Mary Margaret Shoaf, Henry Pollak and Joel Schneider
Consortium for Mathematics and Its Applications COMAP), ISBN 0-912843-76-4

MfA

$$4 \sum_{k=1}^{\infty} \frac{(-1)^{k-1}}{2k-1}$$

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