Nassau County Interscholastic Mathematics League

9	**Grade 9**	**TEAM #**

Mathematics Tournament 2016

No calculators may be used on this part.
All answers will be integers from 0 to 999, inclusive.
One (1) point for each correct answer.

Name ______________________ **School** ______________________ **Score** ________

Time Limit: 45 minutes **Lower Division** *Answer Column*

1. Given three real numbers, x, y, and z, define $(x, y, z)^* = \frac{xy+yz+zx}{x^2+y^2+z^2}$. The value of $(3, 2, 4)^*$ is calculated and expressed as $\frac{a}{b}$ in simplest form. Compute $a + b$.	1.
2. If the numerical value of the area of a circle is 12 times the numerical value of its circumference, compute the length of the radius of the circle.	2.
3. For a rectangular solid, the surface area of the top face is $28\ ft^2$, the surface area of the front face is $24\ ft^2$, and the surface area of a side face is $42\ ft^2$. Compute the volume of the rectangular solid.	3.
4. If x is a positive integer, for how many values of x is $0.25(x - 8) \geq 0.5x - 16$?	4.
5. Given parallelogram $ABCD$. Altitudes $\overline{AF}$ and $\overline{AE}$ are drawn to $\overline{DC}$ and $\overline{BC}$, respectively. If $AB = 12$, $AF = 6$, $FC = 4$, and $AE = h$, compute $100h$.	5.
6. Three-quarters of the first of three integers is equal in value to both $\frac{6}{5}$ of the second integer and $\frac{9}{2}$ of the third integer. When the third integer is subtracted from the second integer, the result is 44. Compute the smallest of the three integers.	6.
7. For three consecutive integers, the positive difference of the cubes of the two larger consecutive integers is 66 more than the positive difference of the cubes of the two smaller consecutive integers. Compute the median integer.	7.
8. In degrees, compute the measure of an angle for which the square of the measure of its complement is 15° more than twice the measure of its supplement.	8.

Turn Over

9	**Mathematics Tournament 2016**	**Grade 9**

Time Limit: 45 minutes **Lower Division** *Answer Column*

9. Compute the units digit of the product: $3^{2015} \cdot 17^{2016} \cdot 29^{2017}$.	9.
10. If x is 10% larger than y, y is 20% larger than z, z is 25% smaller than w, and x is $p\%$ smaller than w, compute p.	10.
11. Compute the sum of the prime factors of 899.	11.
12. A sequence can be called "boring" if all of its terms are identical. Compute the hundredth term of a non-boring arithmetic sequence whose first, second, and fifth terms form a geometric sequence, and whose first term is 2.	12.
13. A baseball fan is somewhere between his home and the stadium. To get to the stadium, he can walk directly to the stadium or he can walk home and then ride his bicycle to the stadium. He rides 7 times as fast as he walks, and both choices require the same amount of time. If the ratio of his distance from his home to his distance from the stadium is written as $\frac{a}{b}$ in lowest terms, compute $a + b$.	13.
14. A checkerboard has 13 rows and 17 columns. Each square is numbered consecutively beginning in the top left and continuing across the rows from left to right in each row. For example, row 1 is numbered 1, 2, 3, …, 17; row 2 is numbered 18, 19, 20, …, 34; row 3 is numbered 35 to 51, etc. If the squares are then numbered consecutively beginning in the top left and continuing from the top down in each of the columns, the numbering would be different. However, some squares would still have the same number. Compute the sum of the numbers that are in the same position no matter which of the two directions is used to number the squares.	14.
15. Three fair dice are tossed and the product of the numbers that appear on the top faces is even. The probability that the sum of those numbers is also even is expressed as $\frac{a}{b}$ in simplest form. Compute $a + b$.	15.

10

Nassau County Interscholastic Mathematics League

Grade 10

TEAM #

Mathematics Tournament 2016

No calculators may be used on this part.
All answers will be integers from 0 to 999, inclusive.
One (1) point for each correct answer.

Name ______________________ **School** ______________________ **Score** __________

Time Limit: 45 minutes **Lower Division** *Answer Column*

1. Compute the perimeter of a rhombus if the lengths of its diagonals are 20 and 48.	1.
2. The coordinates of point P are $(5,2)$ and the coordinates of the image of point P after applying the composite transformation $T_{-3,-1} \circ D_2$ are (a,b). Compute ab.	2.
3. Compute the sum of the distinct prime factors of 16,380.	3.
4. Compute the value of x that makes the following an arithmetic sequence: $(3x-7),\ (5x+2),\ (9x-13)$.	4.
5. If, for the fraction $\frac{3}{5}$, a number is added to the numerator and the same number is subtracted from the denominator, the result is equal to the reciprocal of the original fraction. Compute the number.	5.
6. Two secants, $\overline{ABC}$ and $\overline{ADE}$, are drawn to a circle from external point A. If $AB = 6$ and $BC = AD = 3$, compute AE.	6.
7. Compute the number of sides of a convex polygon that has 20 diagonals.	7.
8. Compute $f(7)$, if $f(2x-5) = 8x^2 - 26x + 66$.	8.

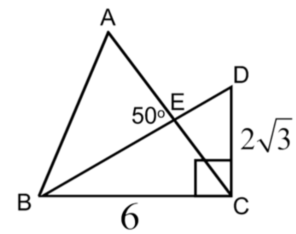
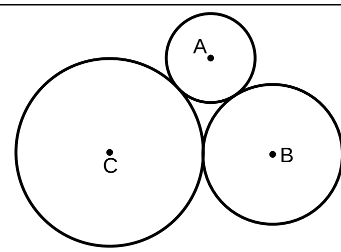
Turn Over

10

Mathematics Tournament 2016

Grade 10

Time Limit: 45 minutes | **Lower Division** | *Answer Column*

9. The centroid of ΔABC is 5 units from vertex A. If $AB = AC$ and $BC = 16$, compute the area of ΔABC.	9.
10. The endpoints of a diameter of a circle have coordinates $(3,4)$ and $(-9,-1)$. A diagonal of a square inscribed in this circle coincides with a diameter of the circle. If the area of the square in simplest form is $\frac{p}{q}$, compute $p+q$.	10.
11. The accompanying diagram contains $\Delta ABC, \Delta BCD$, $\overline{BED}$, and $\overline{AEC}$, with $CD = 2\sqrt{3}$, $BC = 6$, $m\measuredangle AEB = 50°$, and $m\measuredangle BCD = 90°$. Compute the $m\measuredangle ACB$. 	11.
12. For the equation $3 - \frac{5x+3}{x-3} = \frac{x}{x+3}$, let P be the product of the roots and let S be the sum of the roots. Compute $P - S$.	12.
13. In the accompanying diagram, circles A, B, and C are externally tangent in pairs. If the radii of the circles are 4, 6, and 8, respectively, then the area of ΔABC in simplest form is $p\sqrt{q}$. Compute pq. 	13.
14. Compute the number of arrangements of all of the letters of the word SCHOOLS for which there are two consecutive O's but no two consecutive S's.	14.
15. If two positive integers are relatively prime, then their greatest common factor is 1. Compute the minimum sum of three positive integers that are all three relatively prime, but for which any pair of these three positive integers is not relatively prime.	15.

Nassau County Interscholastic Mathematics League

11

Grade 11

TEAM #

Mathematics Tournament 2016

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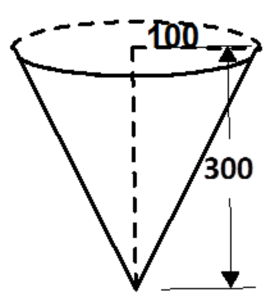
All answers will be integers from 0 to 999, inclusive.
One (1) point for each correct answer.

Name ______________________ **School** ______________________ **Score** ________

Time Limit: 45 minutes **Upper Division** *Answer Column*

1. Compute the largest prime factor of 1287.	1.
2. When the denominator of $\frac{2}{(\sqrt{19}-\sqrt{3})(\sqrt{41}-\sqrt{5})}$ is rationalized and the resulting fraction is written in simplest form, compute the new denominator.	2.
3. If $f(x)=\frac{5x-1}{x-2}$ and $f\big(g(x)\big)=x$, compute $g(14)$.	3.
4. One of the factors of $125x^3-64$ is of the form ax^2+bx+c, where a, b, and c are integers. Compute $a+b+c$.	4.
5. In a classroom, there are more than 10 students. When groups of 6 students are formed, there are exactly 5 students left without a group. When groups of 10 students are formed, there are exactly 9 students left without a group. Compute the smallest possible number of students in the classroom.	5.
6. The expressions 1, k, and $2k+a$, in this order, and where k and a are real numbers, are three consecutive terms of both an arithmetic sequence and a geometric sequence. Compute $k+a$.	6.
7. Let $a_n=a_{n-1}\cdot i$, where $i=\sqrt{-1}$. If $a_1=2-3i$, compute $\sum_{n=1}^{2016} a_n$.	7.
8. A cup, as shown, is a right circular cone with a radius of length 100 and a depth of length 300. It is completely filled with water. If Noah drinks half of the volume of water, then the depth of the water, in simplest form, will be $p\sqrt[3]{q}$. Compute $p+q$. 	8.

Turn Over

Mathematics Tournament 2016

Grade 11

Time Limit: 45 minutes **Upper Division** *Answer Column*

9. Let a and b be the only two integer solutions of the inequality $\lvert x^2 - x - 6 \rvert < 1$. Compute $a^2 + b^2$.	9.
10. Compute the x-intercept of the function $f(x) = \log_2(\log_3(\log_4(x-1)))$.	10.
11. A circle is inscribed in a triangle whose side lengths are 10, 24, and 26. A second circle is circumscribed about this triangle. The ratio of the area of the circumscribed circle to the area of the inscribed circle is $a : b$, where a and b are relatively prime. Compute $a + b$.	11.
12. When $(2x + y + z)^5$ is expanded and like terms are combined, kx^2y^2z is one of the terms, where k is an integer. Compute k.	12.
13. If $\cos^4(x) - \sin^4(x) = \frac{2}{3}$ for $0° < x < 90°$, then $\sin(2x) = \frac{\sqrt{m}}{n}$, where $\frac{\sqrt{m}}{n}$ is in simplest form. Compute mn.	13.
14. Let $f(2n) = 2f(n) \cdot g(n)$, where $\left(f(n)\right)^2 + \left(g(n)\right)^2 = 1$, $f(n) > 0$, and $g(n) > 0$ for all n. If $f(n) = \frac{3}{5}$, then $f(4n) = \frac{a}{b}$, where a and b are relatively prime. Compute $a + b$.	14.
15. A function f is non-constant, is defined for all real numbers x, and satisfies both $f(1+x) = f(1-x)$ and $f(6+x) = f(6-x)$. If $x = 0$ is a root of $f(x) = 0$, compute the number of roots of $f(x) = 0$ in the interval $-100 \le x \le 100$.	15.

Nassau County Interscholastic Mathematics League

12

Grade 12

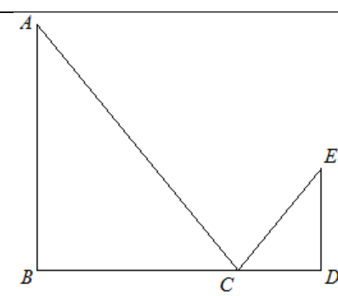
TEAM #

Mathematics Tournament 2016

No calculators may be used on this part.
All answers will be integers from 0 to 999, inclusive.
One (1) point for each correct answer.

Name ______________________ **School** ______________________ **Score** ________

Time Limit: 45 minutes **Upper Division** *Answer Column*

1. The city of Spenciv has a 25% sales tax on all products sold, calculated on the final price, after any discounts have been applied. Kevin's Tires in Spenciv wants to discount their tires by D% such that the final after-tax price is the same as the original (undiscounted, untaxed) price. Compute D.	1.
2. Let $f(x) = \sin^4(x) + \cos^4(x) + 2\sin^2(x)\cos^2(x)$. Compute $f'\left(\frac{2016\pi}{5}\right)$.	2.
3. Compute the number of solutions, (x, y), of $x^2 + y^2 = 50$ for which both x and y are integers.	3.
4. Compute $\lim_{x\to 2} \frac{x^5-2x^4+3x^3-6x^2+8x-16}{x^2-4}$.	4.
5. Given the equation $\log_2(x^3-1) - \log_2(x-1) = \log_2(40201)$. Compute x.	5.
6. The angle, in degrees, represented by the expression $\sum_{k=0}^{2016} k!$ is coterminal with the angle θ, where $0° \le \theta \le 360°$. Compute θ.	6.
7. In the diagram, $\angle B$ and $\angle D$ are right angles, $\angle ACB \cong \angle ECD$, $AB = 240$, $ED = 135$, and $BD = 200$. Compute $AC + CE$. 	7.
8. Let S be the set of 60 points in the plane with polar coordinates $(1, 6n°)$, where n is any integer. Compute the number of distinct regular polygons that can be constructed using only vertices from within set S. (Note: Two congruent polygons in different locations are considered distinct.)	8.

Turn Over

Mathematics Tournament 2016

Grade 12

Time Limit: 45 minutes **Upper Division** *Answer Column*

9. Compute the closest integer to $\frac{1}{10}\left(\sqrt{3}+i\right)^{12}$, where $i=\sqrt{-1}$.	9.
10. For the equation $x^8-Ax^7+Bx^6-Cx^5+Dx^4-Ex^3+Fx^2-Gx+2016=0$, the roots are all integers greater than 1. Compute A.	10.
11. Compute the number of distinct arrangements of the letters of the word ALFALFA that do **not** start with the letter A.	11.
12. Compute the sum of all values of θ, in the interval $0^\circ \le \theta \le 360^\circ$, such that the infinite sum, $1+\sin\theta+\sin^2\theta+\sin^3\theta+\cdots=\frac{5}{7}$.	12.
13. The graphs of $y=x^2+b$ and $y=88x-x^2$ are tangent to one another. Compute b.	13.
14. Let f be a function defined such that $f(x)\ge 0$ for all x, $f(1)=\frac{1}{2}$, and for all nonnegative a and b, $f(a+b)=f(a)+f(b)+2\sqrt{f(a)\,f(b)}$. Compute $f(32)$.	14.
15. If A is any positive real number, compute the greatest possible minimum value of $f(x)=Ax^2-(A+1)x+144$.	15.

M

Nassau County Interscholastic Mathematics League

Mathletics

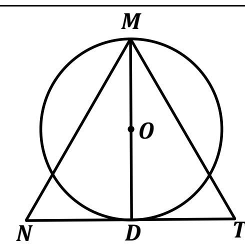
TEAM #

Mathematics Tournament 2016

Calculators may be used on this part.
All answers will be integers from 0 to 999, inclusive.
One (1) point for each correct answer.

Name ______________________ **School** ______________________ **Score** ________

Time Limit: 30 minutes *Answer Column*

1. Given the equations $20x + 16y = 599$ and $16x + 20y = 121$, compute the value of $x + y$.	1.
2. The coordinates of the endpoints of $\overline{AB}$ are $A(-2, -3)$ and $B(5, 11)$. Point C is on $\overline{AB}$ so that the ratio $AC : CB$ is $3 : 4$. If the coordinates of C are (x, y), compute $10x + y$.	2.
3. The length of the shortest segment from the point $(19, -1)$ to the graph of $(x-5)^2 + (y-1)^2 = 8$, expressed in simplest form, is $p\sqrt{q}$. Compute $p + q$.	3.
4. In the diagram, circle O is tangent to equilateral ΔNMT at point D, the foot of altitude $\overline{MD}$. If the area of ΔNMT is $400\sqrt{3}$, and the area of the circle is $n\pi$, compute n. 	4.
5. Starting at the top of a down escalator, it takes Andrea 70 seconds to walk down the escalator to the bottom when it is not operating, and only 30 seconds to walk down the escalator (walking at the same pace) when it is operating. If, starting at the top of the same escalator, Yash just stands still on the operating escalator, it will take him n seconds to reach the bottom. Compute $10n$.	5.

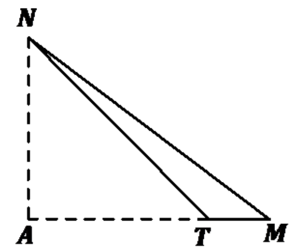
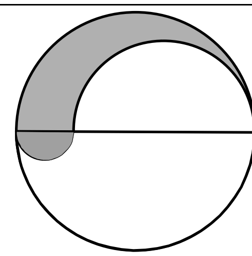
Turn Over

M

Mathematics Tournament 2016

Mathletics

Time Limit: 30 minutes *Answer Column*

6. Compute the units digit of $2^{2016} + 0^{2016} + 1^{2016} + 6^{2016}$.	6.
7. In ΔNMT, $\angle NTM$ is obtuse. The altitude of ΔNMT from vertex N to the line containing $\overline{MT}$ intersects $\overleftrightarrow{MT}$ at point A. Additionally, $NM = 17$, $AT = 14$, and $TM = 1$. Compute the volume of the solid formed by rotating ΔNMT about altitude $\overline{NA}$. Round your answer to the nearest integer. 	7.
8. The figure shown is the union of a circle and two semicircles with diameters of 50 and 150. The ratio of the area of the shaded region to the area of the unshaded region, in simplest form, is $\frac{p}{q}$. Compute $p + q$. 	8.
9. Ajay and Brandon challenge each other to a ping-pong match. Brandon is a much better player at first, but his arm tires quickly. Brandon wins the first game with probability 1, but the chance of Brandon's winning each subsequent game is reduced by 0.2 per game. They play 5 games. Let p represent the probability that Brandon wins at least 4 of these games. Compute $1000p$ rounded to the nearest integer.	9.
10. A group of ten LED lights are placed in a row and each light can be switched between red and blue independently to create a pattern. Compute the number of possible patterns that have no two adjacent red lights.	10.

T

Nassau County Interscholastic Mathematics League

Team Problem Solving

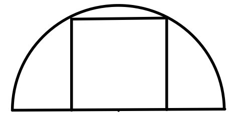
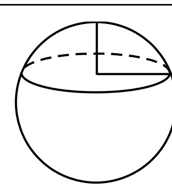
TEAM #

Mathematics Tournament 2016

HAND IN ONLY **ONE** ANSWER SHEET PER TEAM
Calculators may be used on this part.
All answers will be integers from 0 to 999, inclusive.
Three (3) points per correct answer.

Team Copy **School** ______________________ **Score**________

Time Limit: 60 minutes *Answer Column*

1. The fraction $\frac{a}{b}$ is midway between $\frac{3}{7}$ and $\frac{4}{5}$. If the only common positive factor of a and b is 1, compute $a+b$.	1.
2. The perimeter of a square equals the perimeter of a triangle. The lengths of two sides of the triangle are 8 and 17, and the length of a side of the square is 10. The area of the square is k square units greater than the area of the triangle. Compute k.	2.
3. One sixteenth of 2^{56} can be written as 2^m. Compute m.	3.
4. The points $A(1,4)$, $B(3,10)$, and $C(5,12)$ do not lie on a line. An equation for the line of best fit is $3y-6x=8$. Let W equal the average of the slopes of $\overleftrightarrow{AB}$ and $\overleftrightarrow{BC}$. Compute the difference between W and the slope of the line of best fit.	4.
5. A point that is always on the line of best fit has an x-coordinate that is the average of the x-coordinates of the given data points, and a y-coordinate that is the average of the data points' y-coordinates. Let (p,q) be that point on the line of best fit for the points $(15,-6)$, $(12,0)$, $(5,5)$, and $(-1,10)$. Compute $p+q$.	5.
6. The unique prime factorization of 2016 is $2^5 \cdot 3^2 \cdot 7$. Compute the number of positive divisors of 2016.	6.
7. Use the definition that a trapezoid is a quadrilateral with *at least* one pair of sides parallel to compute the area of the smallest trapezoid whose perimeter is numerically equal to its area.	7.
8. A square is inscribed in a semicircle of radius 10 as seen in the diagram. To the nearest whole number, compute how much greater the area of the semicircle is than the area of the square. 	8.
9. A solid sphere is sliced into two parts. The cross-section common to the two parts is a circle of radius 156 cm. If the height of one of the parts is only 104 cm, compute the number of centimeters in the radius of the sphere. 	9.

Turn Over

10. The coordinates of parallelogram $ABCD$ are $A(-12, 45)$, $B(24, -18)$, $C(40, 10)$, and $D(p, q)$. Compute pq.

10.

11. Compute the largest three-digit integer such that if the integer is decreased by 6.25%, the result will also be an integer.

11.

12. There are $10 \times 10 \times 10 = 1000$ ways to arrange three digits in a row using the numbers 0 through 9. When each of those arrangements is placed in a circle, many of the clockwise orders are the same. For example, in the diagram, clockwise arrangements A and B are different, but clockwise arrangements A and C are the same. Compute the number of unique clockwise arrangements of the three digits.

A	B	C
1 3 2	1 2 3	2 1 3

12.

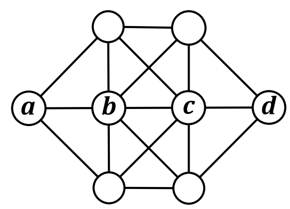
13. Consider the equation: $\sin(x^\circ) = \sin(x^r)$ where x° means x degrees and x^r means x radians. The equation is true when $x = 0$ since $\sin(0^\circ) = \sin(0^r) = 0$. It is also true for many other values of x. Compute the smallest positive value of x for which the equation is true, multiply the result by 100, and then round your answer to the nearest integer.

13.

14. The difference between the arithmetic mean and the geometric mean of two positive numbers is 16. If one of the numbers is 2, compute the other number.

14.

15. Without repetition, place the integers 1, 2, 3, 4, 5, 6, 7, and 8 in the eight circles so that no two adjacent circles (circles with a segment joining them) contain consecutive integers. Compute the sum of the numbers in the circles labeled a, b, c, and d.



15.

16. Triangle ABC is inscribed in circle O whose radius is $20(\sqrt{6} - \sqrt{2})$. If $m\angle A = 45^\circ$ and $m\angle B = 30^\circ$, compute AB.

16.

17. Using only the digits 1, 2, 3, 4, 5, and 6, compute the number of 4-digit numbers that can be formed with a greater number of odd digits than even digits.

17.

18. Compute the units digit in the expansion of 8^{8^8}. (Note that by convention, the exponentiation is performed from top to bottom. That is, $2^{3^4} = 2^{81}$).

18.

19. Let a, b, c, and d be 4 consecutive positive integers such that $a^3 + b^3 + c^3 = d^3$. Compute $a + b + c + d$.

19.

20. The table contains a multiplicative magic square. That means the products of the three numbers in every row, column, and the two major diagonals are the same. Compute the sum of the four missing numbers in the square.

2	9	
	6	1
3		

20.

Nassau County Interscholastic Mathematics League

T

Team Problem Solving

TEAM #

Mathematics Tournament 2016

DO <u>NOT</u> HAND THIS COPY IN. HAND IN THE ONE TEAM COPY.
Calculators may be used on this part.
All answers will be integers from 0 to 999 inclusive.
Three (3) points per correct answer.

Individual Copy

Time Limit: 60 minutes	*Answer Column*
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2. The perimeter of a square equals the perimeter of a triangle. The lengths of two sides of the triangle are 8 and 17, and the length of a side of the square is 10. The area of the square is k square units greater than the area of the triangle. Compute k.	2.
3. One sixteenth of 2^{56} can be written as 2^m. Compute m.	3.
4. The points $A(1,4)$, $B(3,10)$, and $C(5,12)$ do not lie on a line. An equation for the line of best fit is $3y-6x=8$. Let W equal the average of the slopes of $\overleftrightarrow{AB}$ and $\overleftrightarrow{BC}$. Compute the difference between W and the slope of the line of best fit.	4.
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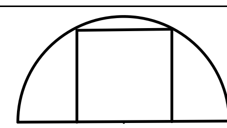
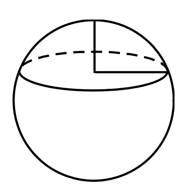
8. A square is inscribed in a semicircle of radius 10 as seen in the diagram. To the nearest whole number, compute how much greater the area of the semicircle is than the area of the square. 	8.
9. A solid sphere is sliced into two parts. The cross-section common to the two parts is a circle of radius 156 cm. If the height of one of the parts is only 104 cm, compute the number of centimeters in the radius of the sphere. 	9.

Turn Over

T

Mathematics Tournament 2016

Team Problems

Time Limit: 60 minutes *Answer Column*

10. The coordinates of parallelogram $ABCD$ are $A(-12, 45)$, $B(24, -18)$, $C(40, 10)$, and $D(p, q)$. Compute pq .

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1 3 2	1 2 3	2 1 3

12.

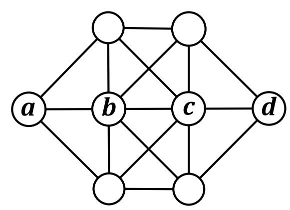
13. Consider the equation: $\sin(x^\circ) = \sin(x^r)$ where x° means x degrees and x^r means x radians. The equation is true when $x = 0$ since $\sin(0^\circ) = \sin(0^r) = 0$. It is also true for many other values of x. Compute the smallest positive value of x for which the equation is true, multiply the result by 100, and then round your answer to the nearest integer.

13.

14. The difference between the arithmetic mean and the geometric mean of two positive numbers is 16. If one of the numbers is 2, compute the other number.

14.

15. Without repetition, place the integers 1, 2, 3, 4, 5, 6, 7, and 8 in the eight circles so that no two adjacent circles (circles with a segment joining them) contain consecutive integers. Compute the sum of the numbers in the circles labeled a, b, c, and d.



15.

16. Triangle ABC is inscribed in circle O whose radius is $20(\sqrt{6} - \sqrt{2})$. If $m\angle A = 45^\circ$ and $m\angle B = 30^\circ$, compute AB.

16.

17. Using only the digits 1, 2, 3, 4, 5, and 6, compute the number of 4-digit numbers that can be formed with a greater number of odd digits than even digits.

17.

18. Compute the units digit in the expansion of 8^{8^8} . (Note that by convention, the exponentiation is performed from top to bottom. That is, $2^{3^4} = 2^{81}$).

18.

19. Let a, b, c, and d be 4 consecutive positive integers such that $a^3 + b^3 + c^3 = d^3$. Compute $a + b + c + d$.

19.

20. The table contains a multiplicative magic square. That means the products of the three numbers in every row, column, and the two major diagonals are the same. Compute the sum of the four missing numbers in the square.

2	9	
	6	1
3		

20.

Nassau County Interscholastic Mathematics League

Tie Breakers

Mathematics Tournament 2016

No calculators may be used on this part.
All answers will be integers from 0 to 999 inclusive.
One (1) point for correct answer.

Name ______________________ **School** ______________________ **Score** ________

Time Limit: *Answer Column*

1.	1.

Name ______________________ **School** ______________________ **Score** ________

Time Limit: *Answer Column*

2.	2.

Name ______________________ **School** ______________________ **Score** ________

Time Limit: *Answer Column*

3.	3.