MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 – NOVEMBER 2017
ROUND 1 COMPLEX NUMBERS (No Trig)

ANSWERS

A) ______________________________

B) (____________ , ____________)

C) (____________ , ____________)

A) Let $P=\sqrt{-125}\cdot\sqrt{-45}$ and $Q^2=P$.
Compute Q.

B) Given: $z=1+i$
Compute the ordered pair (A,B), if $A+Bi=\frac{1}{z}+(-z)+\overline{z}+z^2$.

C) Compute the ordered pair of positive integers (m,k) for which $\frac{1+i\sqrt{k}}{m}+\frac{m}{1+i\sqrt{k}}=1$.

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 – NOVEMBER 2017 SOLUTION KEY

Round 1

A) $P=\sqrt{-125}\cdot\sqrt{-45}=\sqrt{125(-1)}\cdot\sqrt{45(-1)}=\left(5\sqrt{5}\cdot i\right)\left(3\sqrt{5}\cdot i\right)=15\cdot 5\cdot i^2=-75$

$Q^2=P=-75\Rightarrow Q=\underline{\boldsymbol{\pm 5i\sqrt{3}}}$.

B) $\frac{1}{z}+(-z)+\overline{z}+z^2=\frac{1}{1+i}+(-1-i)+(1-i)+(1+i)^2=\frac{1-i}{2}-2i+(1+2i-1)=\frac{1-i}{2}\Rightarrow\underline{\left(\boldsymbol{\frac{1}{2},-\frac{1}{2}}\right)}$.

C) $\frac{1+i\sqrt{k}}{m}+\frac{m}{1+i\sqrt{k}}=\frac{\left(1+i\sqrt{k}\right)^2+m^2}{m\left(1+i\sqrt{k}\right)}=1\Rightarrow 1-k+m^2+2i\sqrt{k}=m+mi\sqrt{k}$

Equating the imaginary components, $m = 2$.

Equating the real components and substituting for m, we have $1-k+4=2\Rightarrow k=3$.

Thus, $(m,k)=\underline{\boldsymbol{(2,3)}}$.

Alternately, let $z=\frac{1+i\sqrt{k}}{m}$. Then: $z+\frac{1}{z}=1\Rightarrow z^2-z+1=0\Rightarrow z=\frac{1\pm\sqrt{1-4}}{2}=\frac{1\pm i\sqrt{3}}{2}$.

$\frac{1+i\sqrt{k}}{m}=\frac{1+i\sqrt{3}}{2}\Rightarrow(m,k)=\underline{\boldsymbol{(2,3)}}$.

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 - NOVEMBER 2017
ROUND 2 ALGEBRA 1: ANYTHING

ANSWERS

A) ______________________________

B) ______________________________

C) (____________ , ____________)

A) Let $y=\frac{5}{9}(x-32)$. If both x and y are positive integers, compute the minimum sum $x+y$.

B) Given: $\begin{cases} A^3-B^3=296 \\ \frac{1}{B}+\frac{1}{30}=\frac{1}{5} \end{cases}$ for integers A and B.
Compute AB^2-A^2B.

C) At 55 mph, I will arrive at my destination in 18 minutes.
If I increase my speed by k mph, I will arrive at my destination in 15 minutes.
Compute the ordered pair (k,d), where d denotes the distance to my destination (in miles).

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 – NOVEMBER 2017 SOLUTION KEY

Round 2

A) Making $x-32$ a positive multiple of 9 and as small as possible, we have $41-32=9$ which produces $y=5$ and $x+y=\underline{\mathbf{46}}$.

B) $30B\cdot\left(\frac{1}{B}+\frac{1}{30}=\frac{1}{5}\right)\Rightarrow 30+B=6B\Rightarrow B=6$

$A^3-B^3=296\Rightarrow A^3=296+216=512=2^9\Rightarrow A=2^3=8$

$AB^2-A^2B=AB(B-A)=8\cdot 6\cdot -2=\underline{\mathbf{-96}}$.

C) $R\cdot T=D\Rightarrow d=55\cdot\frac{18}{60}=55\cdot\frac{3}{10}=\frac{33}{2}=16.5$

$R_{new}\cdot\frac{15}{60}=16.5\Rightarrow R_{new}=66\Rightarrow k=11$

Thus, $(k,d)=\underline{\mathbf{(11,\ 16.5)}}$.

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 - NOVEMBER 2017
ROUND 3 PLANE GEOMETRY: AREAS OF RECTILINEAR FIGURES

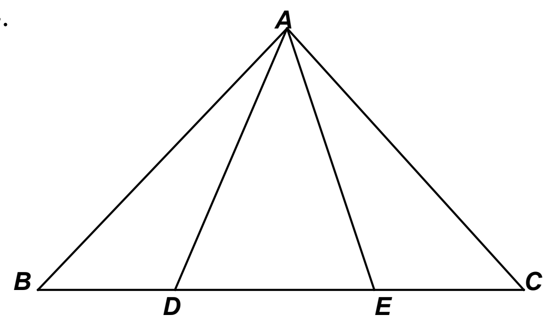
ANSWERS

A) ______________________________

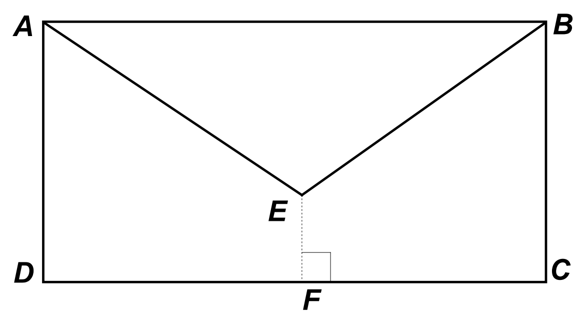
B) ______________________________

C) ____________ : ______________

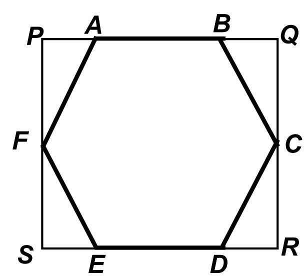
A) In isosceles triangle ABC, $AB = AC = 12$ and $BD = CE = 4$.
If $\text{area}(\Delta BAD):\text{area}(\Delta ADE) = 2:3$, compute BC.



B) The diagram at the right shows the back of a 4" x 9" envelope. If $AE = BE = 5.1$, compute the area of trapezoid $BCFE$.



C) Consider regular hexagon $ABCDEF$ and rectangle $PQRS$, as indicated in the diagram at the right, where $AB = 2 \cdot AP$. Compute the ratio of the area of the hexagon to the area of the rectangle.



MASSACHUSETTS MATHEMATICS LEAGUE
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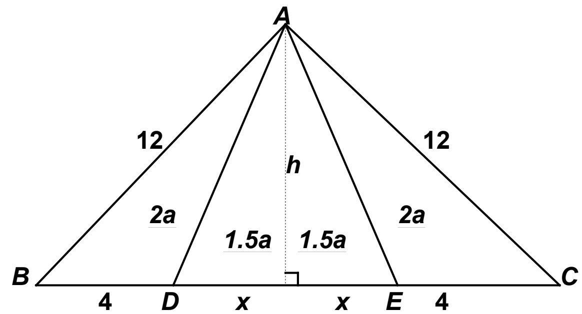
Round 3

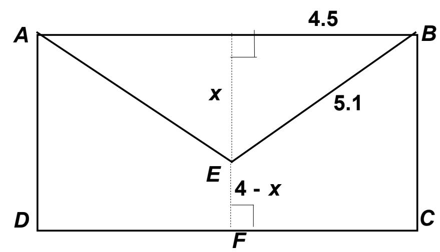


A) $\text{area}(\Delta ACE) = \frac{1}{2}\cdot h\cdot 4 = 2h$.

$\text{area}(\Delta ADE) = 2\left(\frac{1}{2}\cdot h\cdot x\right) = hx$.

$\frac{2h}{hx} = \frac{2}{3} \Rightarrow x = 3 \Rightarrow BC = 4+4+6 = \underline{\mathbf{14}}$.

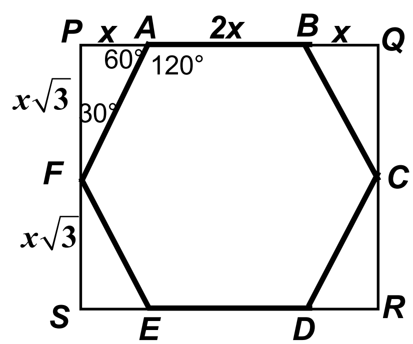
[The information that $AB = AC = 12$ was irrelevant.]



B) Thinking Pythagorean Triple,

$(\_\_,4.5,5.1) = \frac{3}{10}(\_,15,17) \Rightarrow x = \frac{3}{10}\cdot 8 = 2.4 \Rightarrow EF = 1.6$.

Thus, $|BCFE| = \frac{1}{2}4.5(4+1.6) = 4.5(2.8) = \underline{\mathbf{12.6}}$.



C) The area of the rectangle is $(4x)(2x\sqrt{3}) = 8x^2\sqrt{3}$.

The area of the hexagon is $8x^2\sqrt{3} - 4\left(\frac{1}{2}x\cdot x\sqrt{3}\right) = 6x^2\sqrt{3}$.

Thus, the required ratio is 6 : 8 = **<u>3 : 4</u>**.

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 - NOVEMBER 2017
ROUND 4 ALG 1: FACTORING AND ITS APPLICATIONS

ANSWERS

A) ________________________________

B) ________________________________

C) ________________________________

A) Given: $5y(2y-3x)=3x(3x-2y)$
y may be expressed in terms of x, namely $y=kx$, for a rational constant k.
Compute <u>all</u> possible values of k.

B) Compute the sum of the <u>distinct</u> primes in the prime factorization of $6^6 - 2^3 \cdot 3^3$

C) Solve for x. $x^4 = 25x^2 - 144$
Hint: Write a trinomial as the difference of perfect squares.

MASSACHUSETTS MATHEMATICS LEAGUE
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Round 4

A) Noticing that the binomials are opposites of each other makes the job simpler.

$$5y(2y-3x)=3x(3x-2y) \Leftrightarrow 5y(2y-3x)=-3x(2y-3x) \Leftrightarrow 5y(2y-3x)+3x(2y-3x)=0$$

Factoring out the common binomial factor,

$$(2y-3x)(5y+3x)=0 \Rightarrow y=\frac{3}{2}x,-\frac{3}{5}x \Rightarrow k=\underline{\mathbf{\frac{3}{2},\ -\frac{3}{5}}}$$ (or **<u>1.5</u>**, **<u>–0.6</u>**)

Any order is allowed and the lead zero is not required.

B) $6^6 - 2^3\cdot 3^3 = \left(6^3\right)^2 - 6^3 = 6^3\left(6^3-1\right) = 6^3(215) = 2^3\cdot 3^3\cdot 5\cdot 43 \Rightarrow 2+3+5+43 = \underline{\mathbf{53}}$

C) $x^4 = 25x^2 - 144 \Leftrightarrow x^4 - 25x^2 - 144 = \left(x^4 - 24x^2 + 144\right) - x^2 = \left(x^2-12\right)^2 - x^2$

$=\left(x^2-12+x\right)\left(x^2-12-x\right) = \left(x^2+x-12\right)\left(x^2-x-12\right) = (x+4)(x-3)(x+3)(x-4=0)$

$\Rightarrow x = \mathbf{\pm 3,\ \pm 4}$

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 - NOVEMBER 2017
ROUND 5 TRIG: FUNCTIONS OF SPECIAL ANGLES

ANSWERS

A) _______________________________

B) _______________________________

C) _______________________________

A) Given: $\left(\cot 135° + \csc\left(\frac{-5\pi}{6}\right) + \cot\left(\frac{11\pi}{6}\right)\right)^3 = a + b\sqrt{3}$, where a and b are rational numbers. Compute $b - a$.

B) Compute <u>all</u> values of x over the <u>open</u> interval $0 < x < \pi$, for which the expression $\frac{1}{\cos^2 x - 3\sin^2 x}$ is undefined.

C) Compute <u>all</u> values of x (in radians) for which $2\sin\left(4x + \frac{5\pi}{12}\right) - 1 = 0$ and $0 \le x < \pi$

MASSACHUSETTS MATHEMATICS LEAGUE
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Round 5

A) $\left(\cot 135° + \csc\left(\frac{-5\pi}{6}\right) + \cot\left(\frac{11\pi}{6}\right)\right)^3$

$= \left(-1-2-\sqrt{3}\right)^3 = -\left(\sqrt{3}+3\right)^3 = -\left[\left(\sqrt{3}\right)^3 + (3)\left(\sqrt{3}\right)^2(3) + 3\left(\sqrt{3}\right)(9) + 27\right]$

$= -\left[3\sqrt{3}+27+27\sqrt{3}+27\right] = -54-30\sqrt{3} \Rightarrow b-a = \underline{\mathbf{24}}$.

or $-\left(\sqrt{3}+3\right)^3 = -\left(\sqrt{3}+3\right)\left(\sqrt{3}+3\right)^2 = -\left(\sqrt{3}+3\right)\left(6\sqrt{3}+12\right) = -\left(18+36+30\sqrt{3}\right)$
$= -54-30\sqrt{3}$ etc.

B) The expression $\frac{1}{\cos^2 x - 3\sin^2 x}$ will be undefined if and only if $\cos^2 x - 3\sin^2 x = 0$.

$\cos^2 x - 3\sin^2 x = 0 \Leftrightarrow \cos^2 x = 3\sin^2 x = 3\left(1-\cos^2 x\right) \Leftrightarrow 4\cos^2 x = 3$

$\Rightarrow \cos x = \pm\frac{\sqrt{3}}{2} \Rightarrow x = \underline{\boldsymbol{\frac{\pi}{6}, \frac{5\pi}{6}}}$ (over the stated interval).

C) $2\sin\left(4x+\frac{5\pi}{12}\right) - 1 = 0 \Rightarrow \sin\left(4x+\frac{5\pi}{12}\right) = \frac{1}{2} \Rightarrow 4x + \frac{5\pi}{12} = \begin{cases}\frac{\pi}{6}\\ \frac{5\pi}{6}\end{cases} + 2n\pi \Rightarrow x = \frac{1}{4}\cdot\begin{cases}\frac{\pi}{6}-\frac{5\pi}{12}\\ \frac{5\pi}{6}-\frac{5\pi}{12}\end{cases} + \frac{n\pi}{2}$

$x = \frac{1}{4}\cdot\begin{cases}-\frac{\pi}{4}\\ \frac{5\pi}{12}\end{cases} + \frac{n\pi}{2} = \begin{cases}-\frac{\pi}{16}\\ \frac{5\pi}{48}\end{cases} + \frac{n\pi}{2} = \begin{cases}\frac{8n-1}{16}\pi\\ \frac{24n+5}{48}\pi\end{cases}$ Letting $n = 0,1,2$, we have

$\Rightarrow \underline{\boldsymbol{\frac{5\pi}{48}, \frac{7\pi}{16}, \frac{29\pi}{48}, \frac{15\pi}{16}}}$ This listing is in order of increasing magnitude.
Order does <u>NOT</u> matter.

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 - NOVEMBER 2017
ROUND 6 PLANE GEOMETRY: ANGLES, TRIANGLES AND PARALLELS

ANSWERS

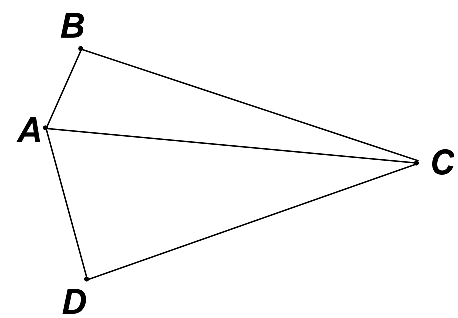
A) ______________________________

B) (____________ , ____________)

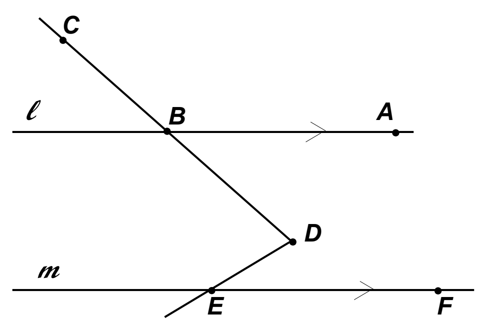
C) ______________________________

A) A base angle in an isosceles triangle with an <u>obtuse</u> vertex angle measures $(100-3x)°$. Compute the <u>minimum</u> integer value of x.

B) A convex quadrilateral $ABCD$ has interior angles in the ratio of 1 : 2 : 3 : 4.
Suppose A is the largest angle and the smallest angle is the opposite angle.
Diagonal $\overline{AC}$ divides $\angle BAD$ into two smaller angles whose measures are in a 5 : 4 ratio.
$\overline{AC}$ divides $\angle BCD$ into two smaller angles whose measures are in a simplified ratio of $m:n$, where $m<n$. Compute the ordered pair (m,n).



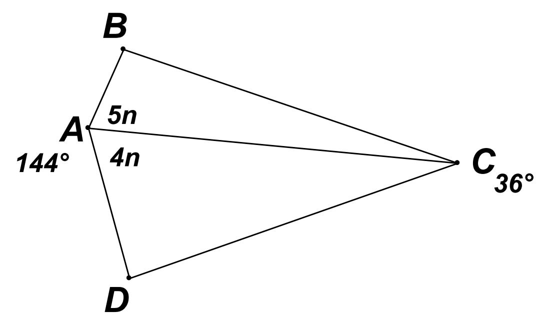
C) Given: $l \parallel m$, $m\angle ABD = x^2 - 7$
$m\angle BDE = 11x + 1$
$m\angle DEF = 5x + 1$
Compute $m\angle ABC$.



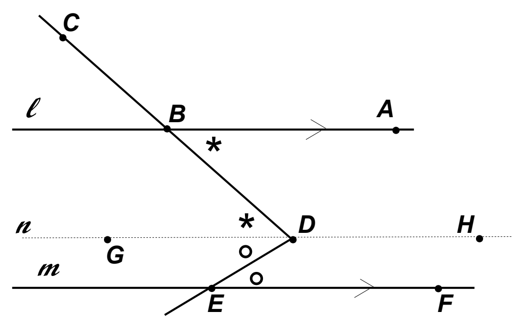
MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 - NOVEMBER 2017 SOLUTION KEY

Round 6

A) $A = 180 - 2(100 - 3x) = 6x - 20 > 90 \Rightarrow x > \dfrac{55}{3} \Rightarrow x_{\min} = \left\lceil 18\dfrac{1}{3} \right\rceil = \underline{\mathbf{19}}$.



B) $10x = 360 \Leftrightarrow x = 36 \Rightarrow$ the largest angle measures 144° and the smallest 36°.
Either $(m\angle B, m\angle D) = (2x, 3x) = (72, 108)$
or, possibly, vice versa.
Suppose $m\angle BAC = 5n$ and $m\angle CAD = 4n$. Then:
$9n = 144 \Rightarrow n = 16 \Rightarrow (m\angle BAC, m\angle CAD) = (80, 64)$
$\Rightarrow (m\angle B, m\angle D) = (72, 108)$
$\Rightarrow (m\angle BCA, m\angle DCA) = (28, 8)$
Thus, $(m, n) = \underline{(\mathbf{2, 7})}$.



C) Draw line n parallel to l and m.
$m\angle EDG = m\angle DEF = 5x + 1$
$m\angle BDG = m\angle ABD = x^2 - 7$

$m\angle BDE = 11x + 1 = * + {}^\circ = (x^2 - 7) + (5x + 1)$
$\Leftrightarrow x^2 - 6x - 7 = (x + 1)(x - 7) = 0 \Rightarrow x = \cancel{-1}, 7$
$x = 7 \Rightarrow m\angle ABD = 7^2 - 7 = 42 \Rightarrow m\angle ABC = 180 - 42 = \underline{\mathbf{138°}}$.

MASSACHUSETTS MATHEMATICS LEAGUE
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ROUND 7 TEAM QUESTIONS

ANSWERS

A) ____________________________ D) ____________________________

B) ____________________________ E) ____________________________

C) ____________________________ F) ____________________________

A) If $\sqrt{-17-144i} = x + yi$, where x and y are real numbers, compute <u>all</u> possible values of $\dfrac{x^2}{y}$.

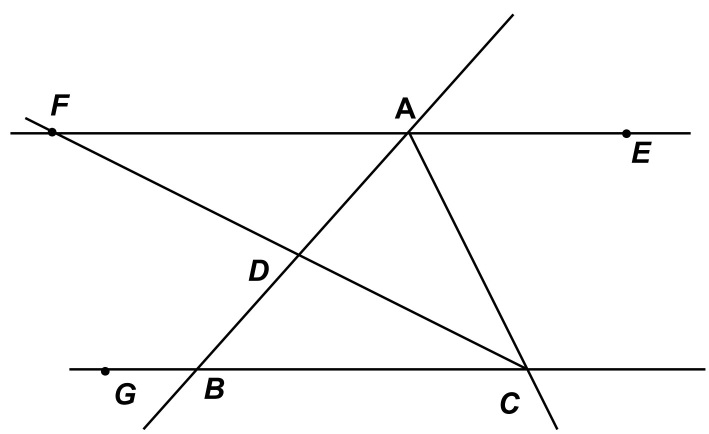
B) The product of two numbers is 2. The sum of the same numbers is 1.
Compute the sum of the cubes of these numbers.

C) In ΔABC, $AC = 4$ and $BC = 6$.
If the area of ΔABC is $3\sqrt{15}$, compute <u>both</u> possible lengths of $\overline{AB}$.

D) How many factors of 4158000 are also factors of 122850?

E) Regular octagon $A_1A_2..A_8$ is inscribed in an origin-centered circle. Its area is $50\sqrt{2}$.
For at least one integer value of i, where $0 < i < 8$, $\overline{A_iA_{i+1}}$ is parallel to the x-axis. How many possible ordered pairs (x, y) are there for vertex A_8, where x and y are <u>not</u> both positive?

F) Given: $\overleftrightarrow{AE} \parallel \overleftrightarrow{BC}$, $m\angle ADC = 87°$,
Ray $\overrightarrow{AC}$ bisects $\angle BAE$
Ray $\overrightarrow{CD}$ bisects $\angle ACB$
Compute $m\angle ABG$.



MASSACHUSETTS MATHEMATICS LEAGUE
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Team Round

A) Solution #1: (Squaring both sides of the given equation)

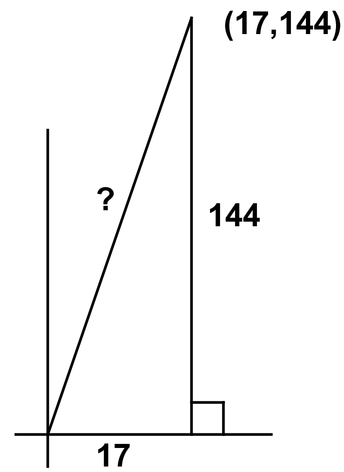
We are looking for *x*- and *y*-values for which $\begin{cases} x^2 - y^2 = -17 \\ xy = -72 \end{cases}$.

Concentrating on the second equation, we note $-8 \cdot 9 = -72$ and $(-8)^2 - 9^2 = -17 \Rightarrow \frac{x^2}{y} = \pm\underline{\mathbf{\frac{64}{9}}}$.

[$-9 \cdot 8 = -72$, but $(-9)^2 - 8^2 \neq -17$]

Solution #2: Algebraic

Solving the system $\begin{cases} x^2 - y^2 = -17 \\ 2xy = -144 \end{cases} \Leftrightarrow \begin{cases} x^2 - y^2 = -17 \\ xy = -72 \Rightarrow y = \frac{-72}{x} \end{cases}$, we substitute for *y* in the first equation. $x^2 - \left(-\frac{72}{x}\right)^2 = -17 \Leftrightarrow x^4 + 17x^2 - 72^2 = 0$. To get an <u>odd</u> coefficient for the middle term, the factors of 72^2 must be of opposite parity, so we gather all the 3's and all the 2s, getting $72^2 = 9^2 \cdot 8^2 = 81 \cdot 64$. The factorization is $(x^2 + 81)(x^2 - 64) = 0 \Rightarrow x = \pm 8,\ y = \mp 9 \Rightarrow$ the same results.



Solution #3: Graphically

$? = 145$, since $145^2 = 17^2 + 144^2$.

Proof: $145^2 - 144^2 = (145 + 144)(145 - 144) = 289(1) = 17^2$

Now these equations are much easier to solve – just ADD.

$\begin{cases} x^2 - y^2 = -17 \\ x^2 + y^2 = 145 \end{cases} \Rightarrow 2x^2 = 128 \Rightarrow x = \pm 8,\ y = \pm 9 \Rightarrow \frac{x^2}{y} = \underline{\pm\mathbf{\frac{64}{9}}}$.

B) Of course, we could find the two numbers. Unfortunately, they are complex numbers, i.e., numbers of the form *a* + *bi*, where $i = \sqrt{-1}$. We would then have to cube each of them, and add these results. Our plan is the avoid all this unpleasantness.

Let the numbers be *x* and *y*.

Consider the expansion of $(x + y)^3 = x^3 + 3x^2y + 3xy^2 + y^3$.

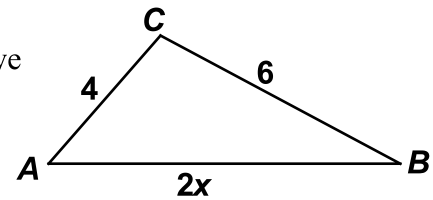
Since $x + y = 1$, we have (re-arranging terms and factoring) $1 = x^3 + y^3 + 3xy(x + y)$.

$\Leftrightarrow 1 = x^3 + y^3 + 3 \cdot 2(1)$

$\Leftrightarrow x^3 + y^3 = \underline{\mathbf{-5}}$.

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 - NOVEMBER 2017 SOLUTION KEY

Team Round



C) Expecting to use Hero's formula, let $AB = 2x$. This will make computing the semi-perimeter s easy. Using Hero's formula, we have

$s = \frac{1}{2}(4+6+2x) = 5+x$.

$$\sqrt{(5+x)(5-x)(1+x)(-1+x)} = 3\sqrt{15}$$
$$\Rightarrow (25-x^2)(-1+x^2) = 135$$
$$\Rightarrow -25+25x^2+x^2-x^4 = 135$$
$$\Rightarrow x^4-26x^2+160=0 \Leftrightarrow (x^2-10)(x^2-16)=0 \Rightarrow x = 4,\ \sqrt{10}$$
$$\Rightarrow AB = \underline{\mathbf{8,\ 2\sqrt{10}}}.$$

Alternately, area of a triangle is given by $\frac{1}{2}ab\sin C$, where C is the included angle.

Thus, the area of ΔABC is $\frac{1}{2}\cdot 4\cdot 6\sin C = 3\sqrt{15} \Rightarrow \sin C = \frac{\sqrt{15}}{4} \Rightarrow \cos C = \pm\frac{1}{4}$.

Using the Law of Cosines, if

$AB = c,\ \ c^2 = 4^2+6^2-2\cdot 4\cdot 6\left(\pm\frac{1}{4}\right) = 52\pm 12 \Rightarrow AB = \sqrt{64}, \sqrt{40} = \underline{\mathbf{8,\ 2\sqrt{10}}}$.

D) We must examine the prime factorization of each number.

$4158000 = 4158(10^3) = 9\cdot 462(10^3) = 9\cdot 6\cdot 77(10^3) = 2^4\cdot 3^3\cdot 5^3\cdot 7\cdot 11$

$122850 = 10\cdot 9\cdot 1365 = 2\cdot 3^2\cdot 5^2\cdot 273 = 2\cdot 3^3\cdot 5^2\cdot 91 = 2\cdot 3^3\cdot 5^2\cdot 7\cdot 13$

Common factors are composed of prime factors of 2, 3, 5, and 7, i.e. of the form $2^a\cdot 3^b\cdot 5^c\cdot 7^d$, where each exponent must be an integer between 0 and the <u>lowest</u> exponent to which that prime occurred in the factorization of each number, inclusive.

Thus, $a: 0...1,\ b: 0...3,\ c: 0...2,\ d: 0...1$

Thus, there are $2\cdot 4\cdot 3\cdot 2 = \underline{\mathbf{48}}$ common factors.

MASSACHUSETTS MATHEMATICS LEAGUE
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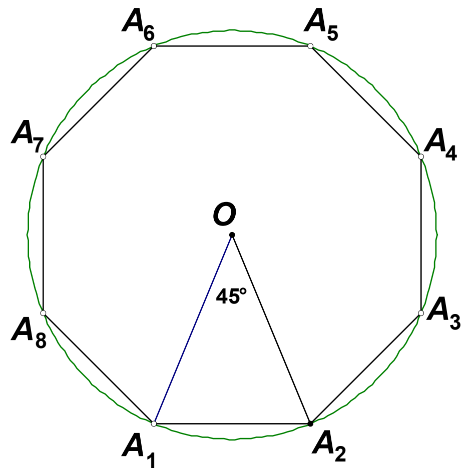
Team Round



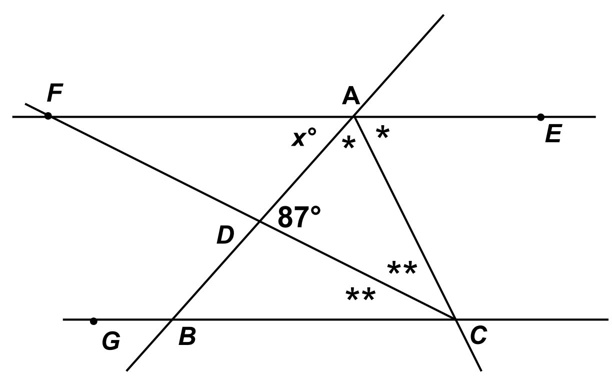
E) As in the diagram at the right, at least one of the sides of the octagon is parallel to the x-axis, in this case $i = 1 \Rightarrow \overline{A_1A_2}$ or $i = 5 \Rightarrow \overline{A_5A_6}$.
The octagon is comprised of 8 isosceles triangles with vertex angles of $\frac{360}{8} = 45°$ and legs equal to a radius of the circumscribed circle. Using $\frac{1}{2}ab\sin\theta$ to calculate the area of a triangle, where θ denotes the included angle, we have $8\left(\frac{1}{2}R^2\sin 45°\right) = 2R^2\sqrt{2} = 50\sqrt{2} \Rightarrow R = 5$ and the coordinates of the vertices must satisfy $x^2 + y^2 = 25$.
In quadrant I, the only candidates are (3, 4) and
(4, 3). These are not allowed; however, there are two additional candidates in each of the other quadrants
by virtue of symmetry with respect to the x-axis $(x, -y)$,
the y-axis $(-x, y)$ and the origin $(-x, -y)$.
Thus, there are **6** possibilities.

F) Let $m\angle FAD = x°$. Then:

$$m\angle DAE = \frac{1}{2}(180 - x) = 90 - \frac{x}{2}$$

$$m\angle BCA = m\angle CAE = m\angle DAC$$

$$\Rightarrow m\angle DAC = \frac{1}{2}\left(90 - \frac{x}{2}\right) = 45 - \frac{x}{4}.$$



Thus, in ΔADC, $\left(90 - \frac{x}{2}\right) + \left(45 - \frac{x}{4}\right) + 87 = 180$

$$\Rightarrow 42 = \frac{3}{4}x \Rightarrow x = 56 \Rightarrow m\angle ABG = \mathbf{124}°.$$

MASSACHUSETTS MATHEMATICS LEAGUE
CONTEST 2 - NOVEMBER 2017 ANSWERS

Round 1 Algebra 2: Complex Numbers (No Trig)

A) $\pm 5i\sqrt{3}$ B) $\left(\frac{1}{2}, -\frac{1}{2}\right)$ C) (2, 3)

Round 2 Algebra 1: Anything

A) 46 B) -96 C) (11,16.5)

Round 3 Plane Geometry: Area of Rectilinear Figures

A) 14 B) 12.6 C) 3 : 4

Round 4 Algebra: Factoring and its Applications

A) $-\frac{3}{5}, \frac{3}{2}$ (or $-0.6, 1.5$) B) 53 C) $\pm 3, \pm 4$

Round 5 Trig: Functions of Special Angles

A) 24 B) $\frac{\pi}{6}, \frac{5\pi}{6}$ C) $\frac{5\pi}{48}, \frac{7\pi}{16}, \frac{29\pi}{48}, \frac{15\pi}{16}$

Round 6 Plane Geometry: Angles, Triangles and Parallels

A) 19 B) $(2,7)$ C) 138°
Degree symbol not required.

Team Round

A) $\pm\frac{64}{9}$ D) 48
(both answers required)

B) -5 E) 6

C) 8, $2\sqrt{10}$ F) 124