

Points & Angles

Newsletter of the Metropolitan Mathematics Club of Chicago
Volume XLIII No. 7, March 2009

A Math Cursed Life


Claran Einfeldt
C Math 2, Inc.

BY PAUL CHRISTMAS

There's an ancient Chinese curse that reads "May your child live in a time of change." If you have been passionately involved in mathematics education over the last 50 years, you may have a deep understanding of what this means, especially with the evolution of technology. We'll take a look back at the teaching and learning of mathematics in an anecdotal humorous way that is shared by people who are "cursed(?)" by their love of teaching and learning of mathematics. We'll also look ahead to proposed changes at the classroom, local, state, national, and international levels. Bring a friend and a sense of humor as we explore our experiences and delight in the anticipation of things to come.

Claran Einfeldt has been a major influence on mathematics education in Illinois. Her love of learning mathematics includes a Masters Degree in Mathematics and her passion for teaching mathematics includes the course work for a Doctorate in Mathematics Education with a Research Methodology Area of Concentration in statistical analysis. She has served as the Assessment Mathematics Consultant for the State Board of Education where she was in charge of developing the ISAT and PSAE including the Illinois Assessment Framework. She then became the Division Administrator for the Division of Mathematics and Science for the ISBE. Claran is currently President of C Math 2, a successful mathematics consulting firm she founded.

Come early for appetizers courtesy of Pearson.

 Since this meeting takes place during Lent, attendees may pre-order fish in place of chicken breast for an additional \$6, provided that the fish is pre-ordered at the time of reservation and that each fish order is accompanied by an attendee's name.



From I-90 & Southbound I-294: Exit at I-190 West to O'Hare; Exit onto North Mannheim Rd.; Take Mannheim Rd. North 2.25 miles.

From Northbound I-294: Exit at West Touhy Ave.; Take Touhy Ave. to Mannheim Rd.; Turn right on Mannheim Rd.

Public Transit: Take the CTA Blue Line to the Rosemont Bus Terminal; Take Pace Bus #223 to Touhy Ave. & Lee Rd.; Walk East on Touhy to Mannheim Rd.

Friday, March 13, 2009

5:30 PM Doors Open, 6:00 PM Social Hour,
7:00 PM Dinner and Talk

**Fountain Blue Banquets &
Convention Center**

2300 Mannheim Rd., Des Plaines
(847) 298-3636

\$31 for Members, \$37 for Nonmembers

Reserve by Noon, Monday, Mar. 9

reservations@mmcchicago.org or (847)
486-4690, day or night, leave a voicemail.

Points from the Interior

By PHIL GARTNER

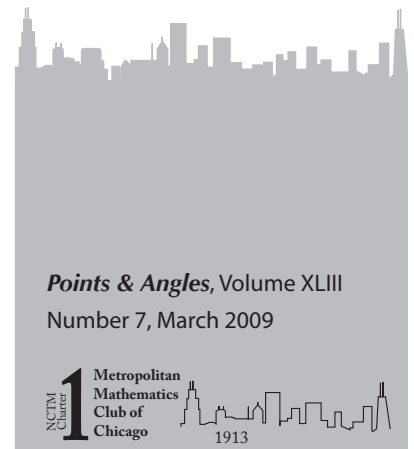
As we progress through the school year our thoughts turn to spring (and Spring Break). We also approach the close of the year for NSML, the North Suburban Mathematics League. Of course this name has become a bit of a misnomer because of the explosion in involved schools from the city and suburbs far from being “north.” If you are not aware, NSML has 55 schools from the area that compete in five meets per year. The culminating event at Evanston Township High School is awesome—all 55 schools meet there for the final meet, whereas the previous four meets typically involve five schools per hosting site.

I would like to remind us that there are some giants who helped build NSML into what it is today. Please forgive me for leaving out names, but a few key leaders who helped start this league include John Benson, Fred Flener, Pete Westergard, and Rich Rukin. Sincere thanks go out to those who are coaches for math teams in the area. The future strength of such leagues depends upon math teachers who commit their time and talents to running these events and writing great questions. If you are not involved, consider getting involved. Petition your school’s administrators to recognize the importance of math-related extracurricular activities to further develop our top students by devoting appropriate resources toward compensating math team coaches. Many schools need more coaches to grow a program or start one. It is a hard job and a long season and coaches need to be recognized and paid for their hard work. I miss my years as a coach, but had to give it up when I went into administration (foolish choice!).

Of course, there are other wonderful math competitions to which several of our members make vital contributions. The ICTM State Math Contest, the American Mathematics Competition (AMC), and the American Regions Math League (ARML) are three wonderful contests. They each afford students an excellent opportunity for problem solving and a chance to be challenged in a way that may not happen in their regular math courses.

So I call upon the members of MMC to begin or continue their support to at least one of these worthy endeavors. It not only makes your students stronger but the experience is so valuable to us as educators, too. The experience will renew your passion for interesting mathematics and give you ideas for problems in the classroom.

I miss my years as a coach, but had to give it up when I went into administration (foolish choice!).



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$e, i, 2\pi$, Oh! Come Explore What These Numbers Can Do

By ISMAEL ZAMORA

“It was a dark and stormy night...” At least that is how John Diehl described this cold and snowy night on January 9th at the Fountain Blue. John started his presentation by reminding us that, “the art of teaching is about asking interesting questions,” a quote he attributed to John Benson. Like all great teachers he started with an opener and asked us to consider some facts we all accept to be true like $i^2 = -1$, $x^a \cdot x^b = x^{a+b}$, $\ln(b^c) = c \cdot \ln(b)$, and others. These facts would form the bases for our up coming explorations.

The next interesting question involved the Loch Ness monster, Bigfoot, Yeti, professional wrestling and i^i . What do all of these have in common? Our consensus was, do they exist, and are they real? And so began our journey into exploration of what we hold to be true.

Our first stop on this journey was $i^2 = -1$. If we believe this to be true, can we then take the natural log of both sides to eventually get $2 \ln(i) = \ln(-1)$? We then were treated to a screen shot of the TI-84's solution (in $a + bi$ mode) to the problem. The solution to $\ln(-1)$ was $3.141592654i$ and $\ln(i)$ was half that or $1.570796327i$. Interesting solutions, to say the least. The calculator seems to believe that there is a solution to a problem we have been taught, and have been teaching, has no solution. How could this be possible?

John then asked us to consider the infinite series that defines the value of $e^a = 1 + a + \frac{a^2}{2!} + \frac{a^3}{3!} + \dots$. With this gem of knowledge, he asked what would happen if we replaced a with bi . This line of thinking eventually leads us to $\cos(b) + i \sin(b)$. He reminded us of the first time he saw Euler's famous formula $e^{\pi i} = \cos(\pi) + i \sin(\pi) = -1$ or $e^{\pi i} + 1 = 0$ and how this simple formula connected some of the most intriguing values in mathematics and leads to such an eloquent solution. With this, he also share with the audience a number of books that have helped him in his explo-

ration of today's topic, including *Dr. Euler's Fabulous Formula* by Paul Nabin. As we continued, we investigated what would happen if both sides of $e^{\pi i} = -1$ are raised to the $\frac{1}{2}$ power and the natural log function is applied to both sides. This gave us a confirmation, not proof, of the calculator's interesting solution.

John's natural curiosity led him to ask if he could raise a real number to imaginary and complex powers and what that would look like. Using our previous results we got our answer: $r^{a+bi} = r^a(\cos(b \ln(r)) + i \sin(b \ln(r)))$.

Finally, we had enough to tackle one of our original questions: does i^i exist and is it real? Once again, the calculator seemed to think so.

Our second major investigation looked at the problem $\sin(x) = 2$. Using our basic assumptions, we deconstructed this question and looked at a triangle of sides 1, 2, and $\sqrt{-3}$ in which 1 is the hypotenuse. Using our knowledge of series we redefined the sin function as $\sin(a) = a - \frac{a^3}{3!} + \frac{a^5}{5!} - \frac{a^7}{7!} + \dots$ and after some manipulation and substitution and simplifying we got $\sin(bi) = \left(\frac{e^b - e^{-b}}{2}\right)i$. We all followed as john took us to a new world using old maps to guide us to the answer to our question of does $\sin(x) = 2$ exist? The road was long and the solution was eloquent: $\sin^{-1}(2) = \frac{1}{2}\pi - i \ln(2 + \sqrt{3})$. We all left questioning our assumptions as always in awe of the simplicity and beauty of the presentation.

I have seen John present many times and I always leave with a new appreciation mathematics and deeper respect for the man who has given me this new appreciation. John Diehl is an incredible presenter and we are lucky to call him a fellow member of this great organization.

$$i = \sqrt{-1} = \sqrt{e^{\pi i}} = e^{\frac{\pi i}{2}}$$

$$i^i = \left(e^{\frac{\pi i}{2}}\right)^i = e^{\frac{\pi i^2}{2}} = e^{-\frac{\pi}{2}}$$

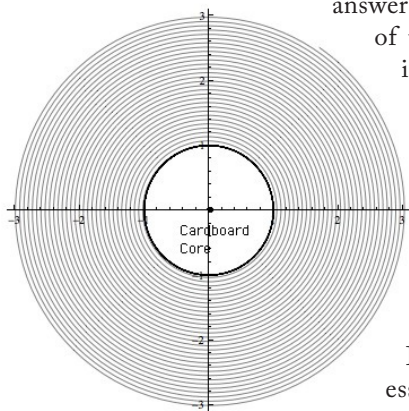
Comparing Solutions of the Paper Roll Problem

By GEORGE PRYJMA

“I was asked to give a humorous introduction, but given the title of the talk that’s too easy,” is how Zalman Usiskin began his warm and witty welcome of our speaker, University of Illinois Professor Emeritus Tony Peressini. Zalman reminisced about the many years that he has worked with Tony (lead author of *UCSMP Precalculus and Discrete Mathematics* as well as co-author of the *Mathematics for High School Teachers: An Advanced Perspective*). Zalman gave Tony’s fascinating mathematical genealogy, tracing from Tony’s doctoral advisors, to their doctoral advisors, and so on, giving a lineage that included Schwartz, Weierstrass, Bessel, and the great Johann Karl Friederich Gauss!

Tony, after thanking Zalman for such a wonderful introduction, began the talk by commenting on his habit of approaching problems from the most complicated perspectives and then being convinced that there are more direct approaches. The material that follows includes Tony’s Archimedean Spiral Model, its solution by the application of Calculus, and two “elementary” solutions provided by Dick Stanley and Patrick Callahan. Amazingly, all of these methods of solution provided, to the nearest thousandth of a foot, identical

answers! The summary of the problem and its solutions provided below is excerpted, with minor edits to fit this format, from the pdf file available at <http://mtl.math.uiuc.edu/>. I thank Dr. Peressini for allowing



its use in this summary.

Joan’s paper Roll Problem. My wife, Joan, was looking at an ad in a grocery store flyer one morning. There was a special on rolls of paper towels available in two in two different size rolls, both of the about a foot wide and perforated into sheets 1 foot long. The cost of the larger rolls was double that of the smaller roll. Joan wanted to know which size was the best buy.

On the basis of the pictures in the ad, I estimated that both types of rolls were wrapped around cardboard cylinders with an outer radius of about 1 inch, and that the outer layer of the larger roll was about 5 inches from the central axis of the cardboard core, while that of the smaller roll was about 3 inches from the central axis. Assuming that both rolls were wrapped with the same degree of tightness around their cardboard cores, say 0.01 inch in thickness for the paper and airspace between layers, I needed to compare how many squares of paper towel were on each of the two roll sizes in order to answer her question.

Because we are assuming that both rolls have the same width and the same tightness, we can model the paper rolls from a side view perpendicular to the central axis of the cardboard core of the rolls. Then the edge of the paper on the roll is an Arithmetic spiral winding out from the cardboard core of radius 1 inch to the outside edge of the roll. The diagram at the left shows this view of a paper roll of outer radius 3 inches.

A Calculus Solution. Since the width of the paper on both rolls is 1 ft., we can compute the amount of paper on each roll by finding the

length of the Archimedean spiral $r = b(\theta) = A\theta$ where θ is the angle in radians swept out as the spiral increases from the radius of 0 to the radius r of the roll. Each wind of the roll will increase r by T ft., the thickness of each sheet, while θ will increase by 2π radians, so $2\pi A = T$, so $A = \frac{T}{2\pi}$ ft. For the thickness of $T = \frac{1}{100}$ in. = $\frac{1}{1200}$ ft. for each layer, $A = \frac{T}{2\pi} = \frac{1}{2400\pi}$ ft.

To reach the surface of the cardboard core, where $r = 1/12$ ft., the angle θ swept out must increase from 0 to the angle $\theta = \theta_1$ where $\frac{1}{12}$ ft. = $\frac{1}{2400\pi}\theta_1$. Therefore, $\theta_1 = 200\pi$ radians. Similarly, to reach the surface of a roll of radius R ft., the angle θ swept out must increase from 0 to the angle $\theta = \theta_R$ so R ft. = $\frac{1}{2400\pi}\theta_R$, which implies that $\theta_R = 2400\pi R$ radians.

In particular, to reach the surface of the 5 in. roll, the angle θ swept out must increase from $\theta = 0$ radians to the angle $\theta = \theta_5$ radians so $\frac{5}{12}$ ft. = $\frac{1}{2400\pi}\theta_5$, so $\theta_5 = 1000\pi$ radians.

The formula from calculus for the arc length of a curve $r = b(\theta)$ in polar coordinates between $\theta = c$ radians and $\theta = d$ radians is $L(c, d) = \int_c^d \sqrt{b'(\theta)^2 + b(\theta)^2} d\theta$.

For the Archimedean spiral $b(\theta) = \frac{T}{2\pi}\theta$ and $b'(\theta) = \frac{T}{2\pi}$, so this arc length is given by

$$L(c, d) = \frac{T}{2\pi} \int_c^d \sqrt{1 + \theta^2} d\theta.$$

We have already observed that $\theta_1 = 200\pi$ radians at the outer edge of the 1 in. cardboard core. Similarly, for the outer edge of a 3 in. roll, $\theta_3 = 600\pi$ radians, and for a 5 in. roll, $\theta_5 = 1000\pi$ radians. Therefore, the length in ft. of a roll of paper of radius 3 in. wrapped on cardboard core of radius 1 in. is $L(\theta_1, \theta_3) \approx 209.440$ ft. Simi-

larly, the length of the 5 in. roll is $L(\theta_1, \theta_5) \approx 628.319$ ft.

Two Elementary Solutions. Dick Stanley and Patrick Callahan developed the following two simple and elegant approaches to a paper roll problem in which the successive layers are modeled as concentric paper cylinders. They developed two different solutions based on that model that they credited to Mickey and Minnie Mouse.

Mickey's approach: Find the number of concentric layers of paper on the roll and then multiply by the length of the middle layer to find the total length of the paper on the roll.

Minnie's approach: Find the area of the paper at the end of the roll by subtracting the area of the core from the area of the entire roll end including the core. This area is equal to the length of the paper on the roll times its thickness.

Note that because, in both of these approaches, the paper roll consists of concentric cylinders of a fixed thickness rather than the Archimedean spiral, our calculus solution may not be the same as those obtained by the approaches by Mickey and Minnie. However, as long as the thickness of the cylindrical layers is very small in comparison to length of the roll, the differences in the computed paper roll lengths may turn out to be negligible. We'll see!

First, let's apply Mickey's approach. Assuming the paper thickness of $T = 0.01$ in., there are 100 layers per inch, so with a cardboard core radius of 1 in., the number of layers on the rolls of radius 3 in. and 5 in. are 200 and 400, respectively. The average radius of the layers in a 3 in. roll is 2 in., while the average radius of the layers in a

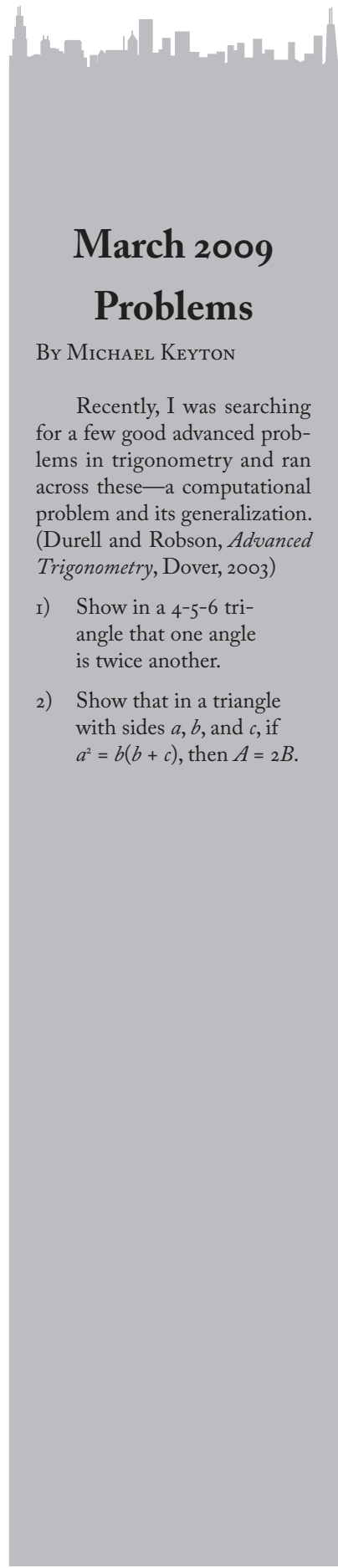
5 in. roll is 3 in. Consequently, the average length of a layer in a 3 in. roll is $(2 \text{ in.})(2\pi) = 4\pi$ in. while the average length of a layer in a 5 in. roll is $(3 \text{ in.})(2\pi) = 6\pi$ in. It follows that the total length in feet of a 3 in. roll is $(200)(4\pi)/12 \text{ ft.} \approx 209.440$ ft. and the total length in feet of a 5 in. roll is $(400)(6\pi)/12 \text{ ft.} \approx 628.319$ ft. These values agree with the values obtained with the calculus solution with the Archimedean spiral model to three decimal places.

Next, let's apply Minnie's idea: For the 3 in. roll with the 1 in. core, the area of the end of the roll minus the area of the 1 in. core is $3^2\pi - 1^2\pi = 8\pi$ square inches. For the 5 in. roll with the 1 in. core, the area of the end of the roll minus the area of the 1 in. core is $5^2\pi - 1^2\pi = 24\pi$ square inches.

From this, we can conclude that the total length in feet of a 3 in. roll is $8\pi/0.01 = 800\pi$ in. ≈ 209.440 ft. and the total length in feet of a 5 in. roll is $24\pi/0.01 = 2400\pi$ in. ≈ 628.319 ft., just as Mickey concluded.

Thus, both Mickey's and Minnie's solutions of Joan's Paper Roll Problem are essentially the same and are very close to the values obtained by calculus.

MMC members present February 6th were treated to a delicious dinner featuring a new chicken dish and a dramatic presentation of oh-so-yummy Flaming Cherries Jubilee. Zalman's introduction of our speaker was masterful, and Tony's presentation was a wonderful mix of serious mathematics and very funny asides. The question of why not solve the problem by finding the number of sheet in each roll just by looking at the labels deemed too trivial to be worthy of exploration.



March 2009 Problems

BY MICHAEL KEYTON

Recently, I was searching for a few good advanced problems in trigonometry and ran across these—a computational problem and its generalization. (Durell and Robson, *Advanced Trigonometry*, Dover, 2003)

- 1) Show in a 4-5-6 triangle that one angle is twice another.
- 2) Show that in a triangle with sides a , b , and c , if $a^2 = b(b + c)$, then $A = 2B$.

Results of MMC Contest No. 24

By ZALMAN USISKIN

This year's contest, "Wheel Number Alignment," found in the December 2008 *Points & Angles*, involved the distribution of the integers from 1 to 100 among 4 wheels with two considerations. First, that each wheel be aligned as closely as possible as measured by the sum of the standard deviations of the sum of squares of eight triads of the numbers on the wheels (any number the entrant wanted could be deleted from each wheel). Second, that the four wheels be balanced by making the four sums of squares of their 25 numbers as close to each other as possible as measured by the standard deviation of the four numbers. The entries were then ranked in each consideration by these standard deviations. The final order of finish in the contest was determined by the sum of the two ranks, lower sums being better.

After last year's record high number of 49 entries, this year we saw a record low number of 5 entries. One entry was disqualified because the entrant did not understand the problem. The four qualified entries finished in the following order:

First prize (\$100):

Daniel and John Summerhays (father and son)
Evanston, IL
alignment score: 31.39
balance score: 0.5 (optimal)

Second prize (\$60):

Jacob Borysiak, senior
Traverse City Central H.S., Michigan
alignment score: 471.82
balance score: 0.5 (optimal)

Third prize (\$40):

Sarah Peluse, sophomore
Buffalo Grove H.S.
alignment score: 100.74
balance score: 7.2

Honorable mention:

Erluo Li, senior
Hinsdale South H.S.
alignment score: 1236.9
balance score: 69.7

We should note that our alignment and balance scores differ from those in two of the entries because we used the specified formula for the standard deviation of a population (divide by n) rather than the formula for the standard deviation of a sample (divide by $n - 1$). This had no bearing on the results. Also, the two entries with the optimal balance score had totally different distributions of the numbers (as seen by the alignment score), showing that there were many ways of attaining the optimal alignment score.

We appreciate the work done by all those who entered. We are sorry this contest did not appeal to more people.

The Winner

The Summerhays' winning entry distributed the numbers as follows:

Wheel 1: central number 100

(46, 52, 67)
(31, 51, 76)
(32, 57, 71)
(8, 41, 87)
(6, 37, 89)
(30, 53, 75)
(40, 49, 73)
(27, 63, 68)

sum of squares: 84587

Wheel 2: central number 99

(19, 42, 85)
(39, 59, 66)
(25, 43, 83)
(20, 55, 77)
(17, 36, 88)
(11, 56, 78)
(35, 58, 69)
(5, 54, 80)

sum of squares: 84587

Wheel 3: central number 98

(9, 64, 72)
(3, 48, 84)
(12, 14, 95)
(2, 23, 94)
(21, 47, 82)
(44, 60, 62)
(18, 50, 81)
(16, 65, 70)

sum of squares: 84588

Wheel 4: central number 96

(13, 28, 92)
(7, 33, 91)
(15, 61, 74)
(34, 45, 79)
(22, 29, 90)
(10, 26, 93)
(1, 4, 97)
(24, 38, 86)

sum of squares: 84588

MMC Conference of Workshops

On January 24th, another great conference was had & we know who's to THANK for that!

All the speakers (because what would there be if you weren't so generous with your time and talents), the

attendees (because with whom do you share if you're not there),

the stuffers (because without them our folders would be empty)

all the volunteers (because how would we get our coffee, food, folders and such),

University of Chicago Lab School (because it would be really cold without a warm, generous place),

Rosa McCullagh (because without her there would be no UC Lab School and all the wonderful things that happened there, including lunch, technology, all the math dept. helpers, lights, etc.),

& John McConnell, (because without him there'd be 100 empty sessions & over 600 lost participants).

(If we forgot you, sorry ... but still thanks so much!)

- Carol & Mary

P.S. Start getting your workshops ready for January 2010! As you know, we'll be in touch.

| | | | |
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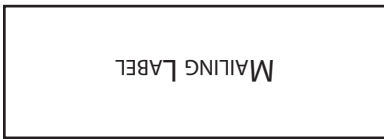
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Upcoming Events

| | | |
|---------------------------------|-----------------|--------------------------------------------------------------------------------------------|
| Fri., Mar. 13 <i>Apr. 18</i> | Claran Einfeldt | A Math Cursed Life <i>MEECAS: Precalculus, Calculus, and CAS</i> |
| Fri., May 8 | Nick Jackiw | Using the Newest (Yet-to-be-Released!) Version of Geometer's Sketchpad to Improve Learning |

Send upcoming event items to ilg@chicagomath.org no later than the date of the MMC dinner meeting preceding the issue in which the item should appear. All items are subject to editing.

Your membership renewal date appears in the upper right corner of the label.



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