New Requirements for the Mathematical Preparation of Elementary Teachers in Massachusetts

Richard Bisk
Professor and Chair
Mathematics Department
Worcester State University

rbisk@worcester.edu
http://worcester.edu/MathDept/Faculty/RichardBisk.aspx
508-929-8962

Questions

1. Are there specific requirements for math coursework in your state's elementary certification requirements?

2. Does your teacher testing process include a separately scored math section?

3. Do elementary schools check the math backgrounds of their new hires?

Massachusetts

In 2007, the Massachusetts Board of Elementary and Secondary Education voted unanimously to upgrade the mathematical requirements for new elementary school teachers.

The changes include a detailed document that describes ***the breadth and depth of mathematics that teachers at the elementary level must not only be able to do, but understand and explain in many ways to students***.

This Presentation

1. Rationale for the changes.
2. Barriers to change.
3. Changes to the regulations and the teacher test.
4. *Spreading the word to higher education*.
5. Changes at my institution – Worcester State University.
6. Data showing test results.

The Problem

Many (perhaps most) elementary school teachers are weak in mathematics. They lack a deep understanding of the math they teach.

- If our third grade teachers read at the sixth grade level, there would be cries for action.

- However, many elementary teachers can’t “do” sixth grade math.

IT'S NOT THEIR FAULT

Elementary are among the most dedicated and hard-working professionals in our society.

How do you teach a mathematical subject when you aren't proficient in it?

You focus on rules, procedures and memorization; or on manipulatives, games and activities that you can't readily connect to concepts.

Why Has This Happened?

Few teacher were asked to learn much math in their preparation programs.

Compare this to the number of courses they take that emphasize reading and writing.

Often the math courses they take are not relevant to the task of teaching elementary school mathematics.

My Epiphany

Elementary Math

is not Elementary

Easy??

- Reading a first grade book is easy
- So teaching reading to first graders is easy

- First grade math is easy
- So teaching first grade math is easy

Mathematical Habits

Math must be taught *at all levels* with a focus on understanding.

Memorization of number facts is essential; but it's easier with understanding.

eg: 8 x 6 = ?

It's double 4 x 6

The habit of memorizing rules and algorithms without understanding is counterproductive. Its negative effects become particularly apparent as students move into middle school.

Teachers who don't understand math well can't teach for understanding.

What Should We Do?

Most preservice elementary teachers need at least three relevant math courses.

(They also need a math methods course to be taken after the math content courses.)

Testing for entrance to the profession should include a specific math section that must be passed similar to what we have in Massachusetts.

Who Agrees?

The **Conference Board of the Mathematical Sciences (CBMS) Mathematical Preparation of Teachers** report published in 2001.

CBMS Recommendations

- ***Recommendation 1.*** *Prospective teachers need mathematics courses that develop a deep understanding of the mathematics they will teach.*

- ***Recommendation 2.*** *Although the quality of mathematical preparation is more important than the quantity, the following amount of mathematics coursework for prospective teachers is recommended.*

  Prospective elementary grade teachers should be required to take at least 9 semester-hours on fundamental ideas of elementary school mathematics.

National Council of Teacher Quality - NCTQ

No Common Denominator - The Preparation of Elementary Teachers in Mathematics by America's Education Schools

June, 2008 report

NCTQ

National Council of Teacher Quality

No Common Denominator: The Preparation of Elementary Teachers in Mathematics by America's Education Schools – 2008

For most programs, we recommend a 3/1 framework: three mathematics courses

designed for teachers addressing elementary and middle school topics and one mathematics methods course

focused on elementary topics and numbers and operations in particular.

NCTQ

A unique stand-alone test of elementary mathematics content that a teacher needs to know is the only practical way to ensure that a state's expectations are met.

The test could also be used as a vehicle to allow teacher candidates to test out of required coursework.

Knowing and Teaching Elementary Mathematics by Liping Ma

Compares mathematical content knowledge for teaching of U.S. and Chinese elementary teachers.

Published in 1999

"…the of Chinese teachers seemed clearly coherent while that of U.S. teachers was clearly fragmented." (p. 107)

U.S. teacher responses reflected a view "…that elementary mathematics is *basic*, an arbitrary collections of rules and facts… The Chinese teachers were concerned with why algorithms make sense…"

(p. 123)

In the United States, it is widely accepted that elementary mathematics is "basic," superficial, and commonly understood. The data in this book explode this myth. Elementary mathematics is not superficial at all, and any one who teaches it has to study it hard in order to understand it in a comprehensive way. (p. 146)

Barriers to Change in Higher Ed

- Our students are passing certification tests now. Why change?
- With Dual Majors – no room for more requirements.
- Math Fear – students won't take more math voluntarily.

More Barriers

- Many select elementary education to limit math demands in their coursework. Besides, elementary math is simple.
- Many fail college math placement tests and need remedial work before taking college math courses.
- Pressure to improve retention rates.

Guidelines for the Mathematical Preparation of Elementary Teachers

"The purpose of these Guidelines is to strengthen the mathematics preparation of teachers at the elementary level as called for by the Massachusetts Board of Education. Most elementary teachers have not had sufficient mathematics content-knowledge preparation for their critical *role* . Our students' math achievement, ahead of the nation but far below that of their international peers, will not rise until mathematics teaching and learning improves vastly—starting with elementary school."

The Changes

"Candidates shall demonstrate that they possess both fundamental computation skills and comprehensive, in-depth understanding of K–8 mathematics. They must demonstrate not only that they know *how to do elementary mathematics, but that they understand and can explain to students, in multiple ways, why it makes sense.*"

"The Board has also directed that beginning January 2009, the Massachusetts Tests for Educator Licensure (MTEL) 'General Curriculum Test' will include a separately scored section of 40 questions on the mathematics specified in the new regulation. This document comprises the Commissioner's Guidelines, articulating the scope and depth of mathematics knowledge—*both skills and understanding—that are expected of elementary teachers and that will be assessed on the test."*

Three Audiences for Guidelines

A. Mathematics Department Faculty

B. Candidates for Licenses at the Elementary Level

C. Coordinators and Faculty from Approved Preparation Programs for Teachers at the Elementary Level

Coursework

"…attaining the necessary level of content knowledge will normally require at least three to four college-level, subject-matter courses, i.e., 9–12 semester-hours, taught by mathematics faculty, potentially in partnership with education faculty. These should be taken after any necessary remedial courses and either integrated with or taken prior to math methods courses. "

"…rather than attempt to define specific courses, the Department recommends these relative weightings for the four strands:

i. Number & Operations 45%
ii. Functions & Algebra 25%
iii. Geometry & Measurement 20%
iv. Statistics & Probability 10%

Was Higher Ed Ready?

Short answer – No. We needed to spread the word and provide support.

After the Board passed the Guidelines the Chancellor of Higher provided WSU with funding to run a series of three workshops for higher education mathematics and education faculty.

Attendance at each ~ 30.

A fourth program with a national speaker (S. Beckmann) drew over 100 attendees from K-12 and higher ed.

Spreading the Word

On Sept 30, 2009, the Commissioners of K-12 and Higher Education in Massachusetts sponsored a full day meeting and invited faculty and administrators from 45 Higher Education Elementary Teacher Preparation programs.

What Courses?

Here's what we do at WSU:

1. Number and Operations (aka arithmetic)
2. Geometry, Measurement, Probability and Statistics
3. Patterns, Functions and Algebra (aka algebra for teachers with explicit connections to arithmetic)

Number and Operations

- Place Value
- Definitions of the four operations and models for explaining them
- Problem Solving
- Development of algorithms, Why they work
- Basic number theory – primes, divisibility, gcf, lcm
- Fractions
- Ratios, Percents, Rates
- Negative Numbers
- Decimal Fractions

Course Goals

- Present arithmetic as a coherent topic based upon definitions and fundamental axioms.
- Shift in student perspective from how to why.
- Arithmetic is not just a bunch of rules to memorize.

Text

Parker/Baldridge-Elementary Math for Teachers Package – includes five Singapore Math student books.

Singapore student books are used to connect teacher understanding to classroom practice.

Math in these books is presented in a clear, coherent and systematic way with an **emphasis on understanding.**

Example - Fractions

Many college students don’t know how to add and multiply fractions. It’s important for teachers to understand that operations on fractions are just extensions of the same operations on whole numbers.

Example - Division

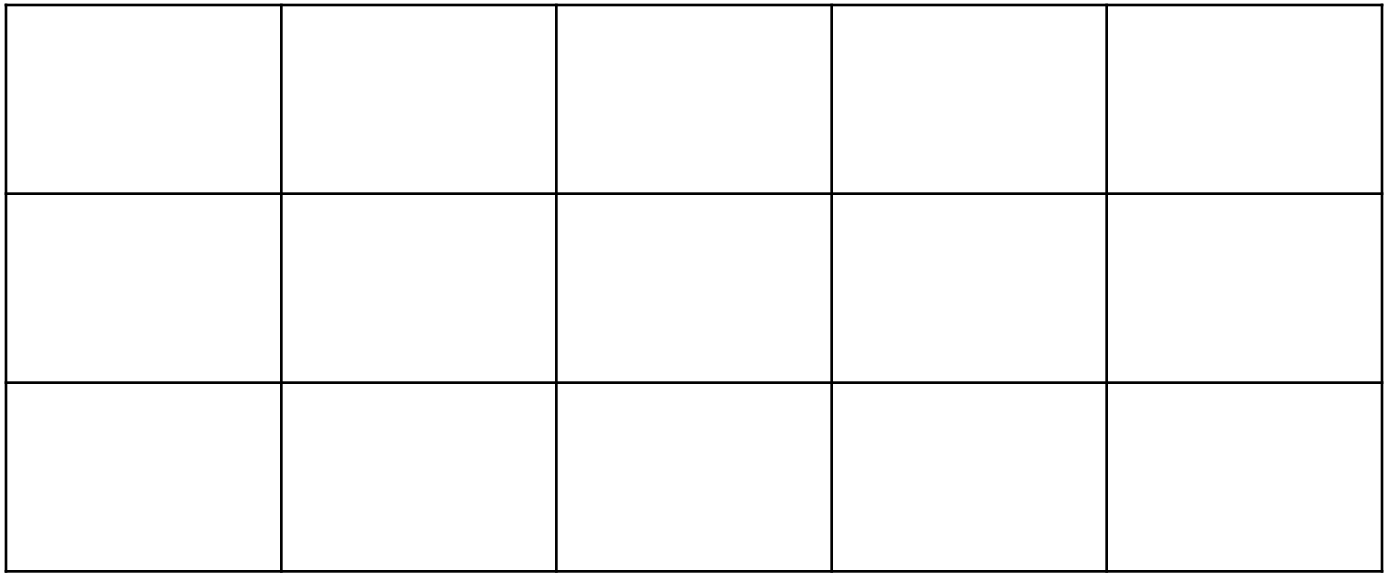
$6 \div 0 = ?$ and why?

Few teachers know the correct answer.

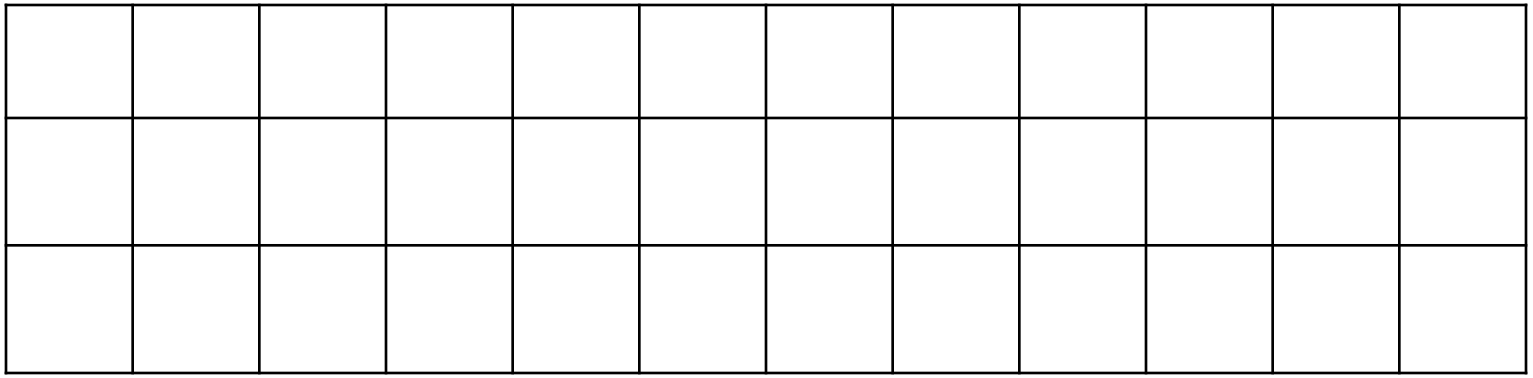
Fewer know why.

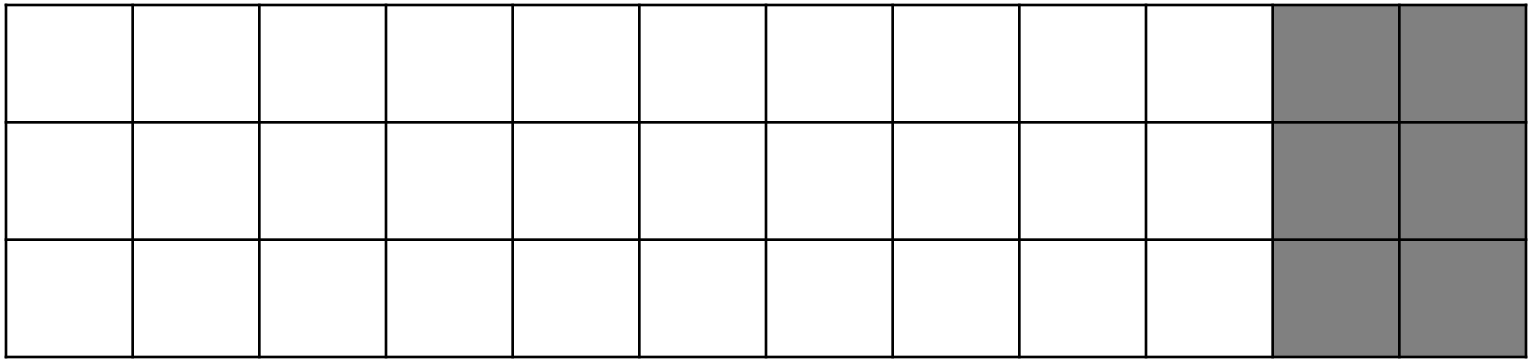
Example - Multiplication

Represent 3 x 5



$$3 \times 12 = (3 \times 10) + (3 \times 2)$$



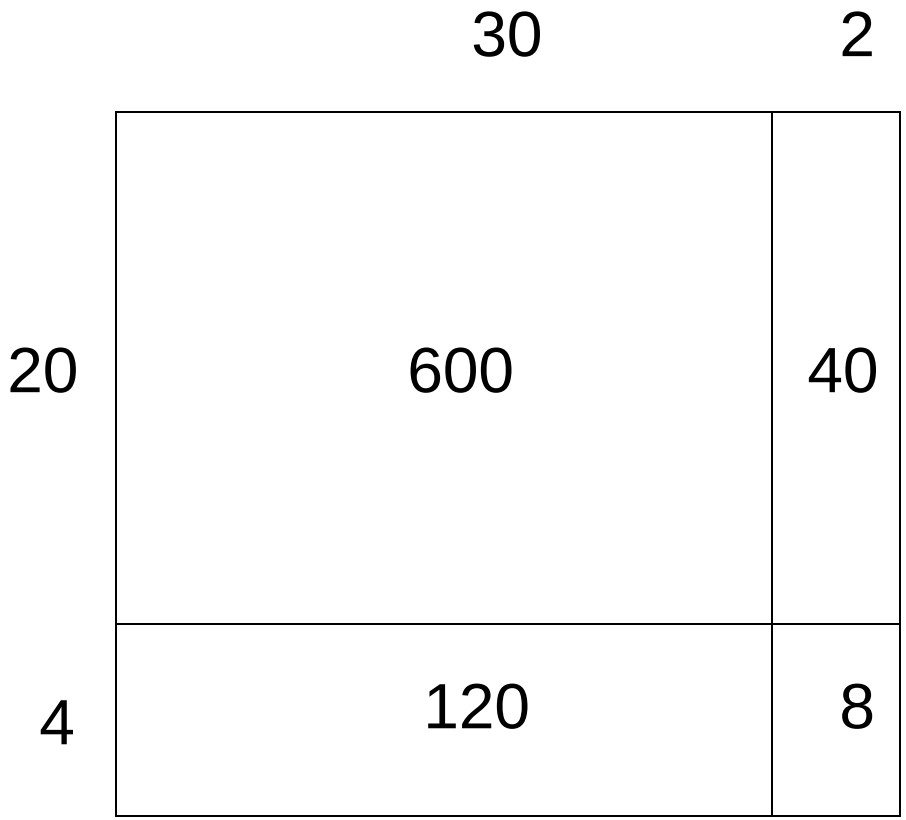


3

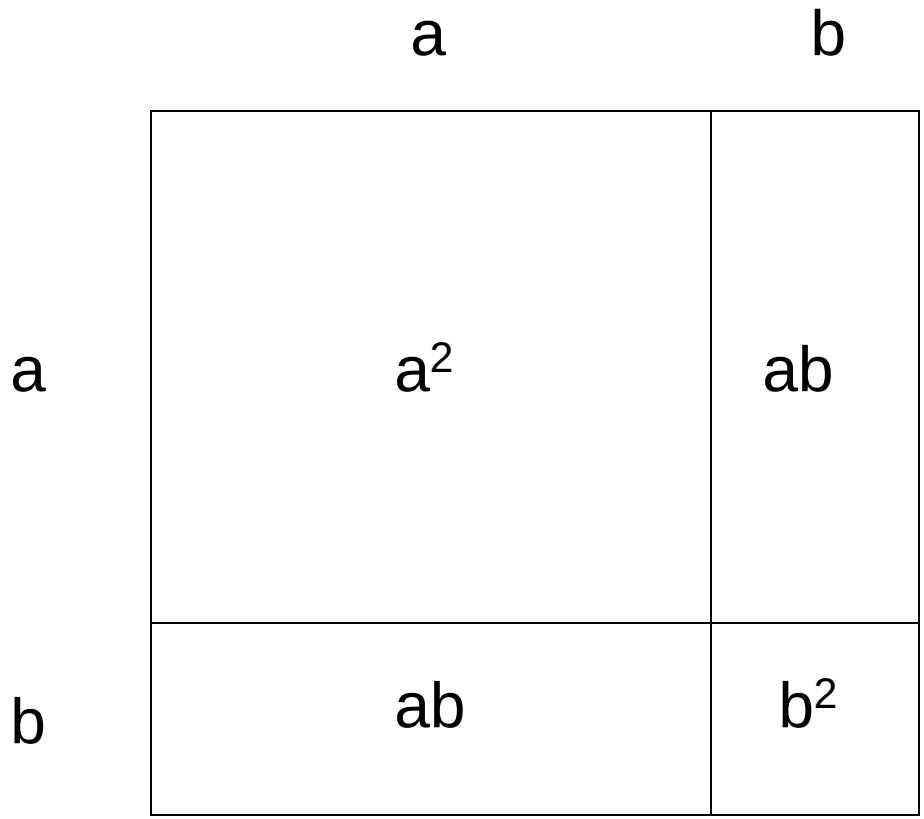
10

2

24 × 32



$$(a+b)(a+b)=a^2+2ab+b^2$$



Back to the Test

First administration – March, 2009

Pass rate – 27%

Board voted to give a condition pass to those within one standard deviation of the cut score. These teachers will need to retake and pass the test within 5 years.

Total pass rate became 39.5%.

Date	# of first time test takers	Percent passing*	# of retakers	Percent passing*
Mar-09	678	39.5		
May-09	574	50.0	28	46.4
Jul-09	658	54.6	193	37.3
Sep-09	364	50.3	222	30.2
Nov-09	657	57.1	285	42.1
Mar-10	842	58.0	437	43.0
May-10	718	53.8	400	31.3
Sept-10	417	60.7	338	53.0
Mar-11	831	57.9	592	40.0
Before	Changes			
May-08	837	75.6	295	32.2
	*includes conditional	pass.	March 2009 full	pass rate was 27%

Sample Question
Online Practice Test

1. In the number 2010, the value represented by the digit 1 is what fraction of the value represented by the digit 2?

A. $\frac{1}{2000}$

B. $\frac{1}{200}$

C. $\frac{1}{20}$

D. $\frac{1}{2}$

5. **Use the expression below to answer the question that follows.**

$$\frac{(32{,}629)(484)}{306{,}751}$$

Which of the following is the best estimate of the value of the expression above?

A. 40

B. 50

C. 400

D. 500

9. **Use the problem below to answer the question that follows.**

> Given that 100 milliliters is equal to approximately 0.4 cup, 205 milliliters is equal to approximately how many cups?

Which of the following expressions models the solution to the problem above?

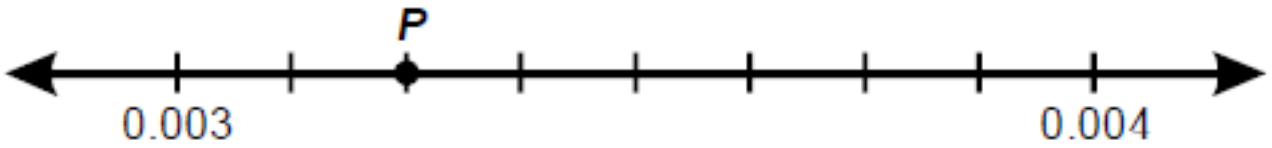
A. $(100 - 0.4)(205)$

B. 105% of 0.4

C. $(205 - 100)(0.4)$

D. 205% of 0.4

10. **Use the number line below to answer the question that follows.**



What number is represented by point *P* on the number line above?

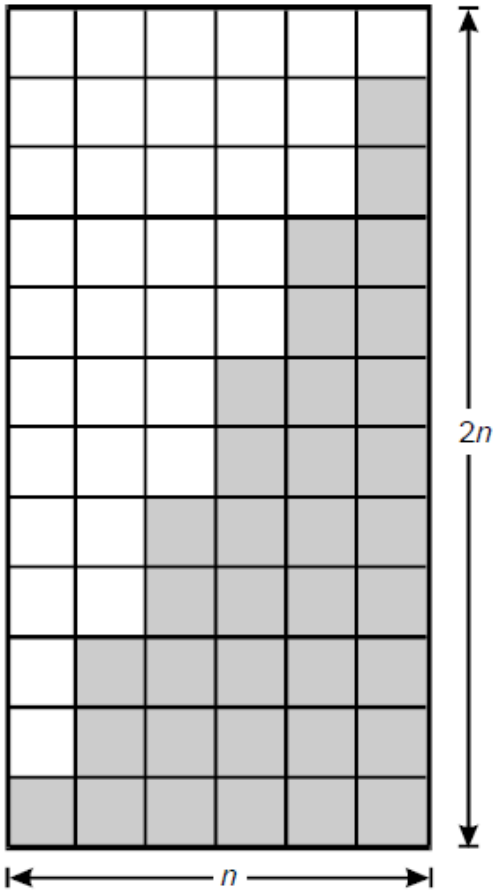
A. 0.0032

B. 0.00325

C. 0.0034

D. 0.00345

16. **Use the diagram below to answer the question that follows.**



The diagram above could best be used to derive a formula for which of the following quantities?

A. the sum of the first n consecutive odd integers

B. the product of the first n consecutive even integers

C. the sum of the first n consecutive even integers

D. the product of the first n consecutive odd integers

20. The expression $(5^{-8} \cdot 7^{-9})$ is equal to which of the following?

A. $\frac{1}{5(35)^8}$

B. $\frac{1}{7(35)^8}$

C. $\frac{5}{(35)^8}$

D. $\frac{7}{(35)^8}$

23. A store that sells handcrafted items takes $3.00 per item plus 40% of the sale price for each item sold. The rest of the money from item sales goes to the craftsperson. All items sold cost $5.00 or more. If p represents the sale price of one item, which of the following expressions represents the amount of money the craftsperson gets for each item sold?

A. $\frac{2}{5}p + 3$

B. $\frac{2}{5}p - 3$

C. $\frac{3}{5}p + 3$

D. $\frac{3}{5}p - 3$

24. **Use the solution procedure below to answer the question that follows.**

$-3x + 25 = 4$

$-3x + 25 - 25 = 4 - 25 = -21 \div (-3) = 7$

$x = 7$

Which of the following is a major flaw in the procedure shown above?

A. The concept of the opposite of a number is confused with subtraction.

B. The equal sign is used to connect expressions that are not equal.

C. The solution contains an error in the arithmetic of signed numbers.

D. The order of operations between subtraction and division is reversed.

25. **Use the diagram below to answer the question that follows.**

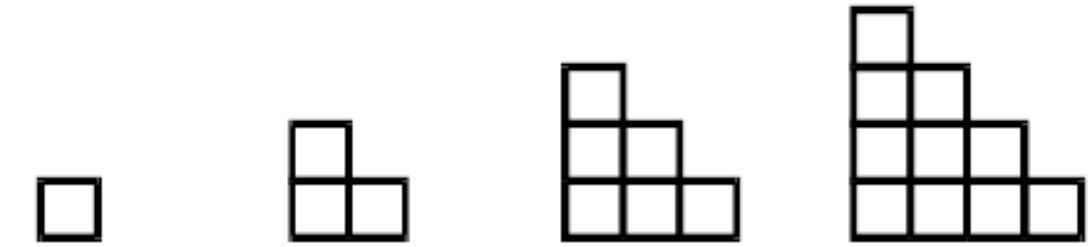


Figure 1 **Figure 2** **Figure 3** **Figure 4**

If the pattern continues, how many more small squares are in figure 100 than are in figure 99?

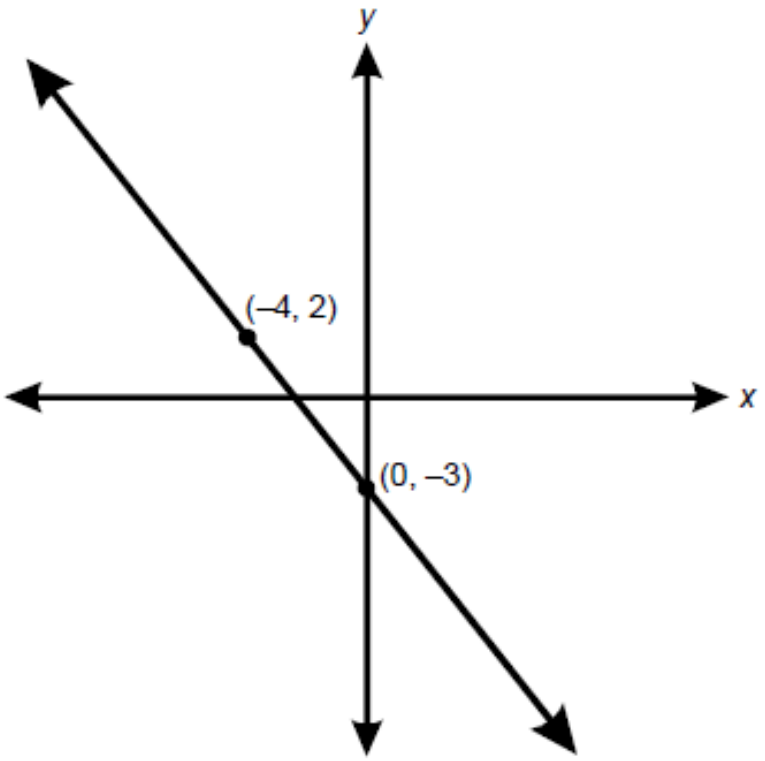
A. 98

B. 99

C. 100

D. 101

30. **Use the graph below to answer the question that follows.**



The graph above represents the equation $Wx + 4y = -12$.
What is the value of W?

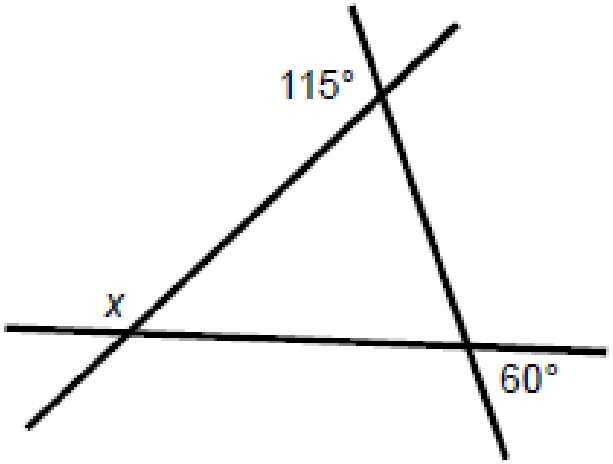
A. –6

B. –3

C. 3

D. 5

40. **Use the diagram below to answer the question that follows.**



Three straight lines intersect to form a triangle, as shown above. What is the measure of angle *x*?

A. 115°

B. 120°

C. 125°

D. 130°

44. A child has a set of blocks, of which 4 are square, 5 are round, and 6 are triangular. The child randomly picks a block from the set and gives it to his sister. The child then randomly picks one more block. What is the probability that the first block was round and the second block was triangular?

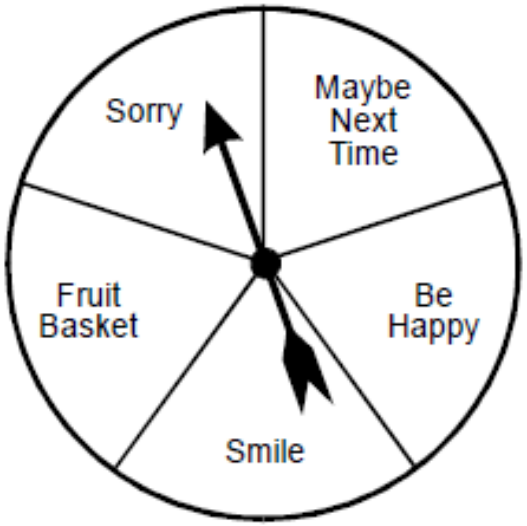
A. $\frac{1}{9}$

B. $\frac{2}{15}$

C. $\frac{1}{7}$

D. $\frac{11}{15}$

45. **Use the spinner below to answer the question that follows.**



The host of a party tells her guests that every time the spinner above lands on the section labeled "Fruit Basket," a guest will win a large basket of fruit. If the 180 guests at the party each spin the spinner once, what is the best estimate of the number of fruit baskets that the host will be giving away?

A. 7

B. 14

C. 36

D. 72

QUESTIONS?

References

Most references in this presentation can be found by going to my home page:

http://worcester.edu/MathDept/Faculty/RichardBisk.aspx