

# Is Math Hard?

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Monday Mathematics #1

Perhaps no other field of study so polarizes children and adults alike as mathematics. Complaints abound—“I hate math.” “I don’t get math.” “Math is hard.” The same is hardly heard of writing, reading, or even biology and chemistry. No, only a dislike of math will get a student almost universal empathy from their elders. Why? Is math really that awful?

To be honest, most people have no need of mathematics in their post-education lives—basic arithmetic can usually tide them through. Even algebra and geometry prove luxuries.

The same is true, of course, for most academic subjects. But math is different from the others. While the fundamentals of mainstream biology can be taught in a series of largely self-contained two-week units, mathematics requires years of prerequisites. When a calculus student can learn in a month how to differentiate an infinite number of elementary functions, he is simply building on what he has learned since pre-algebra.

And why is it so hard? I think some students have never truly learned any mathematics. Mathematics is a way of thinking, a way of reasoning. Difficult math contests are especially enlightening in this regard—a skilled competitor is consistently expected to solve problems of kinds he has never seen before. It doesn’t require a mystical inborn talent, or even necessarily any practice. It only requires a good bag of tricks, and a bit of creative thought. The bag of tricks, of course, isn’t a list to be memorized. It’s simply a set of shortcuts devised over the years to skip unnecessary intermediate steps. You don’t need any, but the more you know, the better. That’s what Monday Mathematics is about.

Creative thought is the harder part. All too often I see students approaching math as simply a set of algorithms to be memorized. This is the most challenging way to view math possible. Instead of viewing each type of solution as a new set of rules for rote learning, we should all try to learn the *reasoning*, not the *result*.

I have seen students find the vertex of a parabola in vertex-form by expanding and completing the square again before reading off the coordinates, without even acknowledging that their algebra was for naught. They aren't even paying attention to the problem—they're just repeating the algorithm they memorized in class. Of course math is hard if each type of problem in the current chapter requires memorizing a list of steps.

### **Finding the Vertex of a Parabola**

1. Complete the square
  - (a) Fully expand
  - (b) Collect like terms
  - (c) Move constant to  $y$  side
  - (d) Add  $\frac{b^2}{4a}$  to both sides
  - (e) Factor
2. Vertex  $(h, k)$  from equation  $y - k = a(x - h)^2$
3. If not in that form, start panicking

Et cetera. But if those steps don't even mean anything to the student, how is he expected to learn those, and hundreds of others? I don't know, math must be hard.

Alternatively, the process could be viewed much more intuitively:

### **Finding the Vertex of a Parabola, II**

1. Change equation into  $y - k = a(x - h)^2$

But honestly, not even the equation requires any sort of memorization. A parabola is just a graph, after all.

### **Finding the Vertex of a Graph (e.g., a Parabola)**

1. Replacing  $x$  with  $x - h$  shifts any graph  $h$  units right
2. Replacing  $y$  with  $y - k$  shifts any graph  $k$  units up

If you understand the reasoning behind The Algorithm the Teacher Used, then you can easily adapt it to every situation. I don't remember anything useful about parabolas except for finding the focus. The rest can be derived quickly—even the focus can be derived, though it's infinitely easier to know certain things cold.

Paul Erdős once said that God has a book of the most beautiful proofs in mathematics. Unfortunately, said Erdős, God (who he called the Supreme Fascist) keeps The Book selfishly to himself, so mathematicians must recreate them one by one.

If math is about anything, it's not about finding the vertex of a parabola. It's about The Book.

$$e^{i\pi} + 1 = 0$$

You rarely need high mathematics to appreciate The Book. Problems can be solved in many ways; the challenge is to find the best. Elegance, simplicity. That's what Monday Mathematics is about. That's what math is about.