Tame the GRE Math Subject Test

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The GRE mathematics subject test is a 66-question multiple-choice mathapalooza used by many mathematics graduate programs as a benchmark to assess knowledge of undergraduate mathematics. At least that's its intent. To me the test seems more like an escapade littered with mathematical trickery and obscurity. Coupled with a lack of resources for approaching similarly sly problems, it's a challenging test to prepare for.

When I took the test about a decade ago, the main study sources were a few outdated prep books (focusing only on content review with a couple of practice exams) and some published sample tests. This limited pool of resources is mostly all that's out there today, and they don't help develop strategies for tackling problems of the style unique to this test.

It wasn't until I hosted prep sessions for students at Harvey Mudd College that I thought of ways I could have better prepared for this exam and how you can too. Here are some strategies to face this challenging test.

Flow with Flow Charts

A major focus of the subject test is making connections very rapidly. A great way to prepare for this is to make content flow charts.

Take a poster board and write a topic on the top; for example, "real analysis." Write down definitions and theorems related to this subject. Then start making connections by drawing arrows when certain phenomena imply others. If the implications are not reversible, explain why with specific counterexamples and general statements. Figure 1 shows an example of one section of such a poster.

Finally, take a mental snapshot of the posters you created. Look at them frequently when studying. You will soon start recalling connections much more quickly.

Patterns Make Perfect

Certain classes of problems tend to appear over and over on the subject test. For instance, students at Harvey Mudd noticed that most practice exams had a quick application of Green's theorem from multivariable calculus. As such, they made a special effort to recognize how to approach this specific problem type.

Other commonly repeated concepts and problems are:

- Switching the order of differentiation (or integration) in a second-order partial derivative (or double integral) to make it easier to calculate;
- Exploiting Taylor series of functions to compute limits quickly;
- Using the central limit theorem to approximate a binomial random variable by a normal random variable; and
- Recognizing that if the sum of every row of a square matrix is a constant k, then k is an eigenvalue of that matrix.
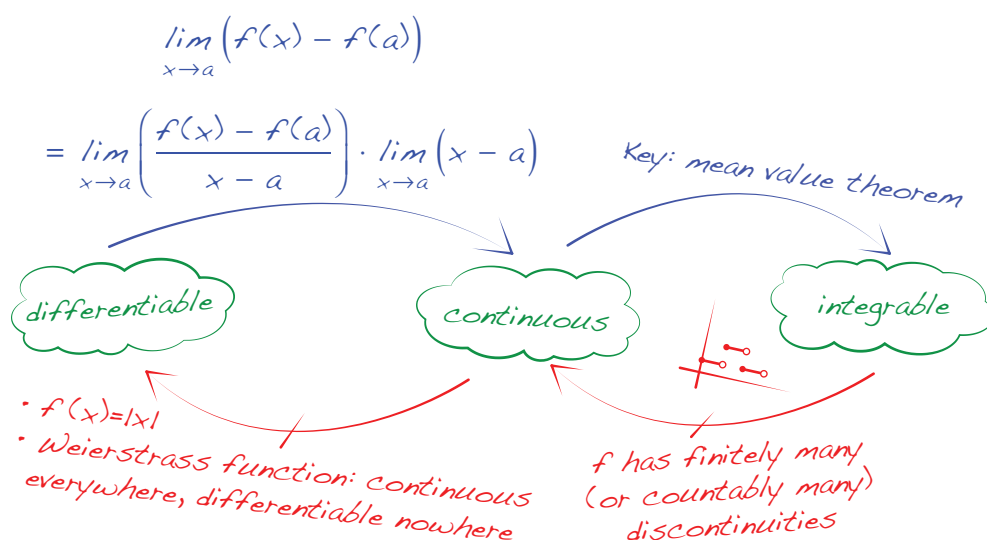

Figure 1. A flow chart for real analysis.

Grading or TA-ing as Training

During GRE training sessions, it became evident that students who had graded for undergraduate classes or were teaching assistants had a sharp advantage over those without this experience. Why? Grading and TA-ing offer the opportunity to revisit concepts in early undergraduate courses and solidify connections between topics, and this is done over an extended time—over the course of a semester for every course you grade or TA for. These connections are precisely the focus of the GRE subject test.

High School Skills for Success?

One of the difficulties of conquering the GRE math subject test is that students are not accustomed to the style of problems: tricky multiple-choice questions. Given the relative lack of study materials available, how does one become accustomed to the problem style?

One strategy is to browse through multiple-choice high school math competitions. A surprising number of problems on the subject test have the same style as problems on the American Mathematics Competitions 12. The Mathematical Association of America has problems collected into volumes from this contest going back decades, one of which is shown in figure 2. Training with these problems can provide solid experience in dealing with the type of thinking and strategy development needed to tackle the subject test.

Rapid Response Recognition

The subject test is only 170 minutes long, so it is important to learn how to complete problems quickly. Many strategies can cut down your response time. One of my favorites is demonstrated in the following example, a variant of a problem that appeared on a practice test:

If f is a twice differentiable real-valued function, then

$$\lim_{h \to 0} \frac{f(x+h) - f(x-h)}{h}$$

is

a) $f'(x)$
b) $2f'(x)$
c) $\frac{1}{2}f'(x)$
d) $f''(x)$
e) $2f''(x)$

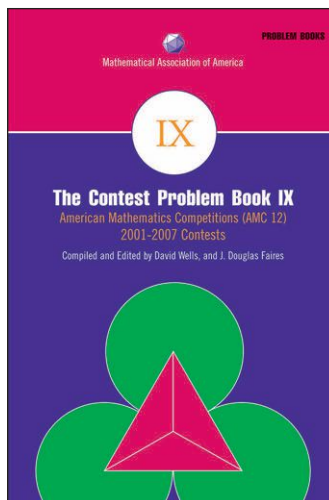Before continuing to read this article, take a few

Figure 2. One of the MAA's AMC 12 problem books.

minutes to work on this problem.

You might have tried to determine what the limit is for a general function f. However, it can be much quicker to pick a function and directly compute the limit. If you let $f(x) = x^2$, then all five answer choices are different, so computing the limit directly with this example will lead to the correct answer choice. Indeed, for this function,

$$\lim_{h \to 0} \frac{f(x+h) - f(x-h)}{h} = 4x,$$

which is $2f'(x)$.

Treat Training as a Course

Many graduate programs take the GRE math subject test score seriously, and when many students start studying for the test, they quickly realize how underprepared they might be. I recommend treating exam preparation as a minicourse during the semester you plan to take it. Reserve time to go over key concepts in core courses such as calculus, multivariable calculus, differential equations, and linear algebra. Work on practice problems regularly and diligently, especially in topics you aren't familiar with. If you have classmates who are taking the exam, form a study group. As time progresses, you will become familiar with the style of exam problems, which will serve you well when test day comes.

These are just a few strategies that can make a profound difference on your GRE mathematics subject test score. Try them out and see how they help! ■

Mohamed Omar is an assistant professor in the Department of Mathematics at Harvey Mudd College. He loves teaching and practicing mathematics, and is a strong advocate for inclusion and diversity in mathematics. See his videos about the GRE math subject test at http://bit.ly/MathGREVids.

The math GRE prep sessions at Harvey Mudd were conducted in conjunction with Ivan Ventura.