

# Math curriculum revision

# Why are the introductory sequences being revised?

- Some of the old sequences (through Math 300 / 301) have gotten out of alignment.
- We wanted the major to be more accessible
- and more flexible (as far as order of courses, mixing regular and intensive versions, etc.)

# Which courses are affected?

- Math 225 has been revised, and an intensive version (Math 226) created.
- Math 230 – 231 are being deleted.
- Math 250, 300, 301 are being deleted.
- The material from all the above courses has been restructured into the new sequences, including the following new courses:
  - Math 255: Analysis 1 (and 256, its intensive version)
  - Math 302: Vector analysis and integration on manifolds
- No other courses are affected.  
In particular, calculus is not affected, and Math 222 is not affected.

# Math 225 / 226: Linear algebra

Math 225 has been revised, with a view to be accessible to incoming students directly after high school calculus courses. Topics include

- Introduction to proofs
- Fields, vector spaces, subspaces
- Linear independence, basis and dimension
- Linear transformations, isomorphisms
- Determinants
- Eigenvalues and eigenvectors
- Inner product spaces, Gram-Schmidt
- Normal and self-adjoint linear transformations, Spectral theorem

Math 226 is an intensive version of Math 225, and assumes familiarity with proofs, or willingness to put in extra work at the beginning of term to catch up.

# Math 255 / 256: Analysis 1

Math 255 can also be taken in the first-semester, though taking Math 225 or 226 first is recommended. Topics include

- Introduction to proofs.
- Limits, sequences, series
- Topology on the real line, compactness, Bolzano-Weierstrass and Heine-Borel theorems
- Continuity, limits of sequences
- Differential and integral calculus, fundamental theorem of calculus
- Taylor series
- Metric spaces, Banach fixed-point theorem
- Ordinary differential equations

Math 256 is an intensive version of Math 255, and assumes familiarity with proofs, or willingness to put in extra work at the beginning of term to catch up.

Math 255 is essentially replacing the 1-variable analysis covered in courses up to Math 301. In particular, Math 305 is not being changed, and will require Math 225 or 226 and Math 255 or 256 (or 301, during transition time).

# Math 302: Vector analysis and integration on manifolds

Math 302 assumes Math 225 or 226, and Math 255 or 256. Topics include

- Topology and limits in  $\mathbb{R}^n$
- The derivative as a linear transformation
- Inverse and implicit function theorems
- Integration in  $\mathbb{R}^n$ , Fubini's theorem, change of variables formula
- Manifolds (as submanifolds of  $\mathbb{R}^n$ )
- Integration with the volume measure
- Differential forms on  $\mathbb{R}^n$
- Tangent spaces, differential forms on manifolds, orientation, integration
- Generalized Stokes' theorem
- Introduction to manifolds beyond  $\mathbb{R}^n$ .

# What is the new sequence?

- Linear algebra with proofs (Math 225 or 226).
- One-variable analysis (Math 255 or 256).
- Multivariable analysis / calculus (Math 302, or Math 120)

The material required for the intro sequence has not changed, it is only moved around. We believe that the new curriculum will be more inclusive, and the clear separation of topics into distinct courses will allow more flexibility for incoming students in several ways, as discussed during the Q&A.

## How do current math majors transition to the new introductory requirements?

For details, see <https://math.yale.edu/curriculum-revision> .

These are the new ways to complete the introductory requirement for the math major:

- If completed Math 120 + 225 + 250, or Math 230 + 231: done with introductory sequence.
- If completed Math 120 + 225: take Math 255 or 256.
- If completed Math 120: take Math 225 or 226 and Math 255 or 256.
- If completed Math 230 in Fall 2020: take Math 225 or 226.

For students who have already started the intro sequences, Math 302 is not required - but it is encouraged for students who have not completed Math 250 or 230-231. Students who have completed 250 or 230-231 will have seen most of the topics; taking Math 302 may still be beneficial, but there may be other useful courses to take, particularly if you're willing to catch up with a few topics on your own.



## What about joint majors?

For details, see <https://math.yale.edu/curriculum-revision>

- CPSC + Math: basically no change  
Old specific courses required: 120, 222 or 225, 244.  
New specific courses required: 120, 222 or 225 or 226, 244
- Econ + Math:  
Old specific courses required: 120, 222 or 225, 300 or 301 (which also need 250)  
New specific courses required: 120, 222 or 225 or 226, 255 or 256
- Math + Phil: no change  
Old and new specific courses required: 120, 270
- Math + Phys: no change  
Old and new specific courses required: 120

## How do I decide between Math 225 vs. 226, and Math 255 vs. 256?

- Both versions are accepted and good preparation for the major. They teach the same topics, only the intensive version might go into slightly more depth, ask more challenging problems on homeworks and exams, or cover some side topics.
- Both will be fun and interesting.
- If you are looking for a bit of extra challenge, and have seen proofs before or are willing to do some catching up, the intensive versions (Math 226, Math 256) may be a good choice.
- If you feel like you would benefit from an explicit introduction to proof writing, or wish to take a less time consuming course, then the regular versions (Math 225, Math 255) may be a good choice.
- You can mix and match these in any way that you like, selecting intensive version for one course and regular version for the other, or switching the order in which you take the courses (we recommend taking linear algebra first, but it can be done either way).
- Moving from intensive to regular version of the same class will be allowed for the first few weeks of the semester.

For more information, visit <https://math.yale.edu/curriculum-revision>

If you have questions about something that is not covered on the site, please visit the Math DUS office hours or write us a note, we will be happy to help. You can find our contact information at <https://math.yale.edu/director-undergraduate-studies>

We will keep expanding the site in answer to frequent questions that we get.

For incoming students, we are creating a site that will help them navigate the new requirements, and make choices about what to take. We expect the site to be available by the end of April.