

UNIVERSITY OF MICHIGAN

What's happening in Michigan introductory math?

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Michigan introductory mathematics

Precalc / Calc I / Calc II

≈4,600

annual course enrollment

Calc I about 2.6K

Calc II about 1.5 K

PreCalc about .5K

18–24

students per section

150+

instructors, mostly GSIs and
postdocs

Coordinated courses taught through small, interactive sections

One Sequence has served essentially all U-M students

Course	Mathematical content
105 Data, Functions & Graphs	Function families, data and modeling Linear, polynomial, exponential, logarithmic, trigonometric
115 Calculus I	Derivatives and applications, optimization, modeling Definite integrals and the Fundamental Theorem
116 Calculus II	Integration techniques and applications, improper integrals Sequences, Taylor series, parametric and polar curves

Followed by 200-level Multivariable Calculus, Differential Equations and Linear Algebra

Emphasis on Conceptual Understanding

Graphical

Read behavior and relationships from graphs

Numerical

Use tables and approximation to reason

Symbolic

Connect formulas to meaning and structure

Verbal

Explain assumptions, solutions and conclusions

Students model real situations, solve problems collaboratively, and communicate their reasoning. Algorithms serve understanding.

Pedagogy and Assessment

Active learning

- team-based problem solving in class, emphasis on conceptual reasoning/modeling.
- ~~Team Homework~~

Repeated opportunities to demonstrate learning

- Repeatable mastery Webwork assessments taken on walk-in basis in Testing Lab.
 - reduced reliance on high-stakes exams, especially in Calc I, Pre-calc.
- Weekly WebWork Assignments, up to six tries per problem
- Midterm (or 2) and Final

Many sources of outside support:

Math Learning Center offers free walk-in tutoring, organizes study groups.
Office Hour Culture.

Coordination and instructor development

Across sections

Shared expectations and pacing
Coordinated curriculum and assessment
Prepared classroom activities

Across instructors

Intensive fall training week
for new GSIs/postdocs
Weekly course meetings
Classroom observation and feedback

Supervision and Training of new GSIs

All new GSIs teach as an apprentice instructor in one of five “Group Rooms”.

Each group room has one experienced “Lead Instructor” with 4-5 apprentices, each handling their own section of 25 students, in a specially designed high-tech room.

GSIs have **four** semesters to become “Advanced GSIs.” Department evaluation.

Reported DFW rates and comparison limits

Course / source	Rate	Population / period
Michigan Math 115 ¹	12% DFW	Overall /2024–26
BTAA Calculus I ²	33.2% DFW	Overall / spring 2019
Gardner introductory calculus ³	34.3% DFWI	Overall / 2018 publication

DFW = D, F or withdrawal. DFWI also includes incomplete grades.

But then...

...Why are we losing students?

Despite the program's strengths and substantial growth in university enrollment

... And why do so many students seem unprepared for our courses?

Challenges and pressures on the program

Staffing many small sections

2015–2023: Our provost required class size below 19 to game a U.S. News & World Report metric.

- Enrollment swings create last-minute hiring.
- Many inexperienced instructors.
- Insane management problem

Burnout and strain on program leaders

- Department faces complaints in the campus paper and Reddit, from students, parents, deans, and advisors.
- These pressures take a lasting toll on the people running the program.

Enrollment and preparation

- Faculty concerns about preparation.
- Other units offering math courses
- Students start taking courses elsewhere for transfer credit

Another Problem... our own hubris!

**We weren't listening to
what client units needed.**

Solution: Ask for help across the university

Collaboration with academic leaders and teaching experts

Education leadership

Associate deans for education

LSA

Engineering

Ross Business School

Vice Provost for Education

Teaching and disciplines

Center for Research on
Learning and Teaching

Science/engineering department
chairs, economics chair, business
school faculty.

A new calculus course for Ross Business School

Currently in **year two of a three year** course development program

Initial leadership

Senior faculty lead the course, at least initially.

Shared commitment

Signed MOU with Ross leadership and with our Center for Research on Learning and Teaching (CRLT)

Development team

Math professor, Math lecturer, Ross professor, Math GSI, two Ross students, CRLT program manager.

Engineering: a new two-course sequence

Linear algebra first, followed by one-variable calculus

Year -1	Engineering self-study: They needed to compress 5 courses to 4. They wanted Linear Algebra first—no prerequisites!
Year 0	Six Math and six Engineering faculty discussed topics. Proposed a new First Year Sequence. The Engineering dean sought feedback from all 11 departments.
Year 1	Each of the two new courses had its own development team: one Math professor, one Engineering professor, one Math GSI, several Engineering undergraduates, with CRLT project managers. Also two Prairie Learn Developers.
Pilot	Both courses piloting this year with about 50 students each. Format: Professor lectures 2x80 minutes/week. Two hour IBL “Labs”.

Math 124: Vectors, Matrices and Applications

First-semester engineering: geometric intuition and algebraic fluency

Geometry and vectors

Vectors as geometry and data.
Build intuition in 2 & 3 dimensions.
Projections, orthogonality and subspaces.
Dot product to determine close-by data.

Computation and applications

Software for LU/QR and interpretation.
Least squares, graphics, robotics
and iterated processes.

[Source: Math 124 objectives, version 3.0](#)

Systems and transformations

Matrices and linear systems.
Linear Transformations,
meaning of eigenvalues/vectors.
Determinants as area/volume scaling factor.

Deliberate scope

Needs only high-school algebra and geometry.
A level playing field for all (we hope).
Much less theoretical (eg, no “echelon form”).
Students go from Math 124 to our more

Math 125: Calculus for Science and Engineering

Single-variable calculus organized around approximation, limits and error, numerical methods

Change and optimization

Derivatives as rates of change.
Differentiation rules, higher derivatives
and optimization.

Approximation throughout

Sequences, series, limits and continuity.
Taylor polynomials and series,
with explicit error estimates.

Accumulation and integration

Definite integrals and numerical methods.
Fundamental theorems of calculus.
Substitution and integration by parts.

Engineering focus

Problems supplied by engineering faculty.
Numerical tools used regularly.
Informal reasoning, not proof.

Similarities and differences with existing courses

WHAT CONTINUES

Conceptual understanding

Emphasis on the numerical point of view

Mastery assessment

Interactive learning

Two-hour, GSI-led labs with carefully developed projects

WHAT CHANGES

Faculty-led lectures

Rely more on experienced teachers.
GSI-led labs are faculty-designed.

A new assessment platform

PrairieLearn replaces WeBWork

NEXT CHALLENGE How do we scale this next year?

Transfer credit: preparation and student success

Data shows students with transfer credit for Math are not succeeding at U-M. Business School, Engineering College first to formally bring to our attention.

New Policy, Fall 2027:

U-M students take U-M courses, unless there's a reason.

Students transferring in get a different course number, proficiency test if needed for program.

Massive Communication Program:

- A year discussing internally and with clients.
- A year discussing with the college.
- A summer “Road Show” to every college/department.
- This year communications to students, external partners.