

Technology Recommendations for Calculus

The Mathematics Department at GVSU greatly values the productive use of technology to help students learn mathematics. All instructors in the department are encouraged to seek out positive ways to use technology in all its forms to assist in teaching and learning. The introductory calculus sequence (MTH 201, MTH 202, MTH 203) in particular is a place where technology can be used to great effect in improving student learning.

While instructors retain the freedom to use different forms of technology in the calculus sequence, we recommend the following specific technologies for use in these courses.

MTH 201 and MTH 202

In MTH 201 and MTH 202, we recommend the use of:

- **Geogebra** (<http://geogebra.org>), a free and open-source graphing and modeling software package, for graphing functions and exploring visual ideas;
- **Wolfram|Alpha** (<http://wolframalpha.com>), a “computational knowledge engine” on the web, for assisting with symbolic calculations; and
- Any **spreadsheet program** (such as Microsoft Excel, Google Spreadsheets, or the spreadsheet feature in Geogebra) for numerical calculations and analysis.

All three of these tools are either free (in the case of Geogebra, Wolfram|Alpha, and Google Spreadsheets), or inexpensive and ubiquitous (such as Excel), and all three can be used in concert to assist in helping students make sense of calculus concepts.

In terms of hardware, we recommend that students use portable computing devices such as laptops, Chromebooks, tablets, or smartphones equipped with the above software. Many students also use graphing calculators, and generally we recommend that these be permitted in class – but the department mandates no specific model of calculator.

The recommendation of portable devices (rather than calculators) is based on issues of cost, usability, and computing power. Since many students already own a portable device, there is little to no additional cost incurred by students in using them for class. The output produced by the above software is more readily used by other applications such as presentation software and email than output from a calculator. And computers and tablet devices generally provide more computing power for complex or large calculations than calculators.

MTH 203

In MTH 203 (Calculus 3) we recommend the continued use of portable computing devices (see above) along with a **computer algebra system** (such as Maple or Mathematica) for graphical and symbolic computation, or the 3D capabilities of GeoGebra for graphical and symbolic computation. GVSU maintains a site license for *Mathematica* that allows all GVSU faculty and students to download and install the software locally on their own computers, free of charge. For instructions, see <http://www.gvsu.edu/clas/labresource/mathematica-7.htm>.

General recommendations for the use of technology in calculus

We recommend that computer software should be used in contexts where students are actively using the software to construct their own understanding of course concepts. Instructors are encouraged to demonstrate the use of the software before having students use it, but the primary use of technology should be in the context of active student work. For example, students can use the software to visualize functions, construct numerical models from data, or use Wolfram|Alpha or *Mathematica* to automate difficult algebraic calculations.

The department strongly suggests that the weekly lab session for MTH 201, 202, and 203 be used exclusively for active student work, using the technology listed above to solve problems that use authentic data, real-world contexts, or computational complexity, so that the use of technology is valuable in their solution.

The presence of portable computing devices in the classroom can raise concerns regarding student disengagement during class times and test security during timed assessment periods. There is no single solution to such issues, but the department encourages all instructors to seek positive solutions that do not impede the students' use of the technology for legitimate reasons. For example, switching phones and tablets to "airplane mode" during tests allows students to use their devices without accessing the internet.

Finally, other technologies are used within the department for classroom management and assessment. **WeBWork** is an online homework system that allows students to work exercises online that are graded and recorded automatically. **Blackboard** is GVSU's course management system that can be used for recording grades, submitting work, and transmitting announcements. The department maintains a repository of **classroom response devices** or "clickers" that can be borrowed for use in classroom sessions. Other technological products are available; please contact the department's Instructional Resources Coordinator, for more information.