

A Scalable Hybrid Introductory ODE Course

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Description

Students

- 500-600 University of Maryland students per semester,
 - 3-4 large lectures with 100-250 students,
 - 1-2 small Honors section.
- 60% engineering majors, most of the rest being science, math, and computer science majors.
- Most are sophomores, but many are first-year students with AP.
- pilot classes at Montgomery Community College.
- AP course at Poolesville High School.

Description

Material

The course has four main parts:

- First-Order Equations
- Higher-Order Linear Equations
- First-Order Linear Systems
- First-Order Autonomous Planar Systems

Three applications are woven throughout the course:

- Tanks and Mixtures
- Motion
- Population Dynamics

Principle 1: Multistream Material

The course material is available in several formats.

- Live Lectures and Discussions
- On-Line Exercise with Short Answers and Detailed Solutions
- On-Line pdf: Main Text, Paul's Notes
- On-Line Videos: Khan Academy, MIT Opencourseware, In-House
- On-Line Matlab Resources: MathWorks, In-House

Most on-line material is available to the students through a single portal.

- The external links in the portal are curated.
- The portal is linked to Google Analytics.

There is no paper textbook. This removes a huge constraint!

Principle 1: Multistream Material

Google Analytics

Google Analytics provides information that guides our planning.

- About 67% of the students do not use videos as a primary resource. Students say that this is because of its difficult searchability.
- About 33% of the students use video resources regularly. This is why providing videos is important.
- Most of these prefer the short videos over the long ones. This is why simply videoing lectures is not ideal.
- Almost all students use the exercise environment.
- Almost all students use a pad or phone to view the materials. Laptops are also widely used. Desktops less so.
- Chrome is the most popular browser on all platforms.

Principle 2: Hybrid

The course uses three approaches to stimulate student learning:

- a sage on a stage,
- a guide by the side,
- a peer that is near. (This is the most important!)

While these approaches are often presented as in opposition, it can be more effective to use them in harmony. Specifically, we employ:

- **Lectures** (sage);
- **Discussion Group Work** (guide/peer);
- **Matlab Team Projects** (peer);
- optional **Guided Study Session Group Work** (guide/peer);
- optional **Drop-In Tutoring** (guide).

Principle 2: Hybrid

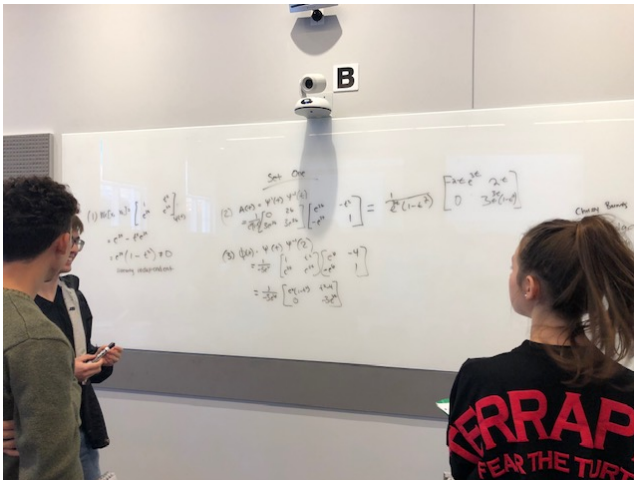
Lectures

There are either two 75 minute or three 50 minute **Lectures** per week. Most weeks fifteen minutes at the beginning of one lecture is used to give a ten minute quiz. The TAs help with the quiz.

- Large lectures have 100-250 students.
- The lecture format is needed to cover everything on the syllabus.
- This is where most material is introduced to the students.
- Examples are emphasized, but details of steps that the students should already know are skipped or skimmed over. However, more details are provided in the text.
- This format is effective only if the students are ready to absorb information at this pace. That will not be the case without the other formats!

Principle 2: Hybrid

Discussions



Principle 2: Hybrid

Discussions

There is one 50 minute **Discussion** each week run by the TAs.

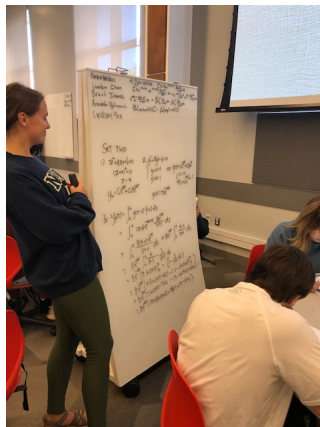
- Each TA oversees a discussion section of 16-24 students.
- Each section is split into four groups of 4-6 students each.
- These groups work on three sets of **group work exercises** that are posted on the class website the day before.
- For each set they have about 10-12 minutes to write their solutions on a whiteboard, after which their TA photographs their effort.
- There is a brief discussion of the solutions led by a TA before going on to the next set. Detailed solutions are posted afterwards.

Each set of **group work exercises** either:

- builds upon on the most recent quiz,
- builds upon material from the most recent lectures.

Principle 2: Hybrid

Discussions



Principle 2: Hybrid

Matlab Projects

Six **Matlab Projects** are assigned during the semester. These each have a strong graphical component.

- The first is done solo. This gives an assesment of each student's Matlab skill.
- The other five are done in teams of (usually) two that are assigned by the TA so that each team has a basic level of Matlab skill.
- Problematic teams are changed by the TA for subsequent projects.
- Matlab is used in all sophomore-level Mathematics courses: Multivariable Calculus, Linear Algebra, and Differential Equations. There is a one-credit Matlab course for those who feel they need it. (Many students have used it in high school.)

Principle 2: Hybrid

Guided Study Sessions

Guided Study Sessions are run evenings by undergraduate GSS Leaders who have recently done well in the course.

- The Counseling Center runs the GSS Program, trains GSS Leaders, and monitors their activities.
- Before each lecture the Leaders plan a set of group work exercises based upon the material to be covered in the lecture. This plan is submitted to the instructor for feedback before the lecture.
- They attend the lectures.
- They run their one hour session based upon the feedback to their plan and upon what they see in the lecture.

Between 10 and 25 students from a class of 200 will attend each GSS. Many students love this program. I do too!

Principle 2: Hybrid

Drop-In Tutoring

There are many **Drop-In Tutoring** services on campus. However, two are the most widely used.

- The **Mathematics Department Tutoring Room** offers daytime tutoring by either a graduate or an advanced undergraduate student. It also provides help with Matlab.
- The **Keystone Tutoring Center** is run by the Engineering School. It offers evening tutoring twice a week by an advanced undergraduate student who attends either a discussion section or (even better) the lectures of one of the classes. This coordination makes it more effective than most other drop-in tutoring services. Its hours of operation do not usually conflict with those of the GSS program.

Principle 2: Hybrid

Peer-to-Peer

Peer-to-Peer engagement benefits both the explainer and the explainee!
It is the great force-multiplier that happens when no instructor is present!
The challenge is to promote it!

- Multistreaming of the material enables it.
- Providing many detailed examples enables it.
- The Matlab Projects try to create peer it.
- Posting the Discussion Group Work early promotes it.
- The Discussion and GSS Group Work and the Matlab Teams help build a community that promotes it.

When peer-to-peer engagement is mobilized, everything else becomes more effective! For example, students can follow lectures delivered at a faster pace and at higher level than otherwise.

Principle 3: Executive Thinking

Executive thinking is about making decisions. It is about being able to choose the right tool for a given task. By requiring students to make such choices, they are motivated to learn each tool better!

- Analytical, graphical, and numerical methods are presented.
- Often there are many methods that can be applied to a problem.
- Quiz and exam questions do not telegraph the method to be used.
- Applications do not telegraph the method to be used.

This is not a “cookbook course” filled with recipes that merely have to be memorized. Rather, it is a chef school.

Principle 3: Executive Thinking

For example, when faced with a higher-order nonhomogeneous linear equation there are at least seven analytical methods presented.

- Zero Degree Formula
- Key Identity Evaluations
- Undetermined Coefficients
- Constant Coefficient Green Function
- Laplace Transform
- Variation of Parameters
- General Green Function

Principle 3: Executive Thinking

When faced with computing the matrix exponential for a first-order linear system with constant coefficients there are at least four methods presented.

- Two-by-Two Formulas
- Natural Fundamental Set Method
- Diagonalization
- Eigen Solutions

Principle 3: Executive Thinking

When faced with a first-order autonomous planar system there are at least five methods presented.

- Linearization about Regular Stationary Points
- Determining if it is Conservative anywhere
- Finding any Semistationary Orbits
- Finding an Integral
- Finding the Nullclines

Principle 4: Formative and Summative Evaluations

Course grades are based on 800 points, distributed as follows.

- three in-class exams (300 pts, summative)
- final exam (200 pts, summative)
- six Matlab Projects (100 pts, summative)
- quizzes (100 pts, formative/summative)
- discussion group work (100 pts, formative/summative)

The first three are standard. We give more detail about the last two.

Principle 4: Formative and Summative Evaluations

Exams and Matlab Projects

There are three in-class exams worth 100 points each plus a final exam worth 200 points.

- If one of their in-class exam scores is 15 points below the other two and also 15 points below half their final exam score, and if the final exam score is above the C– cutoff then the low score is replaced by the average of half their final exam score and their next highest in-class exam score. This is called the “bombs away” rule.
- Final Exam bonuses can raise the course grades of those who do well on the final exam.

There are six Matlab Projects worth 20 points each.

- Their best five project scores count toward their course score.

Principle 4: Formative and Summative Evaluations

Quizzes

There are typically 11 or 12 ten-minute quizzes worth 10 points each.

- Their best ten quiz scores count toward their course score.
- Quiz scores are adjusted by a “tens digit” rule. Namely, if a quiz score is below the “tens digit” of the exam score covering that material then it is raised to that value. For this rule to apply at least one of the relevant quizzes scores must be at least a 5.
- The “tens digit” rule allows students to let quizzes take on a **formative** role. It also allows them to budget their study time without compromising their course grade.
- There is no “tens digit” rule for quizzes after Exam 3.
- Because of their **formative** role, students with testing accommodations typically do not use them to take quizzes.

Principle 4: Formative and Summative Evaluations

Discussion Group Work

There are typically 14 discussion section meetings. There are 10 points available during each for group work.

- Their best ten group work scores count toward their course score.
- Group work scores are adjusted by a “tens digit” rule. Namely, if a nonzero group work score is below the “tens digit” of the exam score covering that material then it is raised to that value. (This rule is subject to experiment.)
- The “tens digit” rule allows students to let group work take on a **formative** role. It also allows them to budget their study time without compromising their course grade.
- There is no “tens digit” rule for group work on material covered after Exam 3.
- Points for group work seems essential to get students to buy into it!

Results and Observations

Observations

- Many students have trouble adjusting to the information-rich multistream format. Those who don't do poorly on the first exam.
- By the second exam almost all of the students have adjusted.
- By the final exam the scores are higher than historic averages.
- Faculty evaluations went up with the new material.
- Teaching executive thinking requires thoughtful effort.
- While all instructors use multistreaming, not all fully engage every dimension of the hybrid approach. Sections that engage more dimensions typically do better on the common final exam.

Results and Observations

Performance

The course grades distribution for the 182 students who completed the course last semester (Fall 2019) was:

- 80 A's (44.0%)
- 56 B's (30.8%)
- 29 C's (15.9%)
- 9 D's (4.9%)
- 8 F's (4.4%)

Initially 207 students were registered.

- The DFW rate (which administrators like to track) was about 20%.
- More significantly for long-term success, the AB rate was about 66%!

Results and Observations

Links

You can visit the website for this class at

<http://www.terpconnect.umd.edu/lvrmr/2019-2020-F/Classes/Math246.shtml>

From there you can link to the exam, quiz, and group work material. That includes solutions to all of the in-class exams and quizzes.

From there you can also link to the day-by-day syllabus that shows how the material was covered.

You will not be able to see the text, the solutions to the group work exercises, or the GSS group work, all of which are posted on internal University sites.

Questions

Fiinal Remark. These innovations were developed while paying close attention to how the students in the course respond to them. Care must be taken when adopting them to other courses at other institutions. However, I think the principles behind them are sound.

Thank You!

Questions?