MATH 2BL: APPLIED LINEAR ALGEBRA LABORATORY

Foothill College Course Outline of Record

Heading	Value
Effective Term:	Summer 2024
Units:	1
Hours:	3 laboratory per week (36 total per quarter)
Corequisite:	Completion of or concurrent enrollment in MATH 2B.
Advisory:	Experience in using mathematics software such as MATLAB, Octave, Python Excel, Mathematica.
Degree & Credit Status:	Degree-Applicable Credit Course
Foothill GE:	Non-GE
Transferable:	CSU/UC
Grade Type:	Letter Grade (Request for Pass/No Pass)
Repeatability:	Not Repeatable

Student Learning Outcomes

- Students will apply the theory they learn(ed) in MATH 2B to analyze their ideal mathematical model, produce an ideal mathematical solution, and then compare their calculated solution to real-world data they collect.
- Students will complete all stages of the applied mathematical modeling process to analyze and model a real-world problem related to their academic and career interests.
- Students will document their understanding of how linear algebraic theory can be used as part of a larger process of applied mathematical modeling on real world problems related to their academic and career interests.
- Students will transform their real-world problem into at least one of the four fundamental problems in applied linear algebra - (1) matrix multiplication problem, (2) linear systems problems, (3) least squares problems, or (4) eigenvalue problems.

Description

Laboratory course to accompany MATH 2B. Introduces students to live, hands-on laboratory and design experiences as part of common mathematical modeling processes. Students learn how to interact with the material world or from data drawn from the material world, using the tools and data collection techniques. Students learn to use linear algebra to create, develop, and analyze mathematical models of real-world problems related to their academic and career interests.

Course Objectives

The student will be able to:

1. Apply appropriate sensors, instrumentation, and/or software tools to make measurements of physical quantities.
2. Design, build, implement, and debug laboratory experiments using common equipment or methodologies to study real-world phenomena.
3. Demonstrate the ability to collect, analyze, and interpret data to form and support conclusions.
4. Create and solve ideal mathematical models of real-world experiment using at least one of the four major problems of applied linear algebra.
5. Identify the strengths and limitations of theoretical mathematical models as predictors of real-world behavior by validating a relationship between measured data and underlying mathematical model.
6. Communicate effectively using the language of linear algebra.
7. Work effectively, constructively, and collaboratively in groups.

Course Content

1. Apply appropriate sensors, instrumentation, and/or software tools to make measurements of physical quantities
   a. Collect physical measurements of real-world system variables
   b. Organize and store physical measurement using appropriate software
   c. Prepare physical data to be analyzed using appropriate software
2. Design, build, implement, and debug laboratory experiments using common equipment or methodologies to study real-world phenomena (students will pick from one of the following projects)
   a. Combine component parts together to build functional spring-mass systems to collect physical displacement data for mechanical vibrations problems
   b. Prototype and measure electric behavior of resistor circuits to study voltage-current relation for each individual circuit component for electric circuit analysis problems
   c. Create database of digital photos in appropriate format to be imported into MATLAB software for digital photography and image processing problems
   d. Create database of spline vertex points stored in appropriate format for 2-D or 3-D cubic spline problems
   e. Other applied projects that align with student's academic and career interests
3. Create and solve ideal mathematical models of real-world experiment using at least one of the four major problems of applied linear algebra
   a. Introduce useful mathematical notation, define relevant variables, impose appropriate mathematical assumptions, and focus on a subset of important problem characteristics while ignoring other aspects of the problem
   b. Create an ideal model in the form of one of the four major problems of linear algebra, which are matrix-matrix multiplication problems, linear-systems problems, least-squares problems, or eigenvalue problems
   c. Decide on which approaches are most productive and search for the relevant linear algebraic theorems that can be brought to bear to solve the problem
   d. Manipulate or simplify relevant formulae to address the various constraints in their model and use appropriate techniques to create ideal solution to mathematical modeling problem
4. Identify the strengths and limitations of theoretical mathematical models as predictors of real-world behavior by validating a relationship between measured data and underlying mathematical model
   a. Make explicit connections between the ideal solution and the collected data from laboratory experimentation process by mapping their mathematical results to real-world counterparts

and contextualize their solution in terms of the real-world situation
   b. Decide that mathematical model is acceptable
5. Demonstrate the ability to analyze and interpret data to form and support conclusions
   a. Discuss where inaccuracies show up in the mathematical model
   b. Evaluate what discrepancies are acceptable
   c. Propose next steps to improve accuracy of model
6. Communicate effectively using the language of linear algebra
   a. Prepare laboratory workbook
   b. Present laboratory software tools with proper documentation
   c. Create final laboratory report documenting progress and conclusions
7. Work effectively, constructively, and collaboratively in groups
   a. Structure individual and teamwork activities
   b. Assign roles, responsibilities, and tasks
   c. Monitor progress and meet deadlines
   d. Integrate individual contributions into a final deliverable

Lab Content

Same as Course Content, above.

Special Facilities and/or Equipment

Spring-mass chains for static displacement measurements, a McCusker apparatus providing a spring-coupled pair of pendula, Tracker physics software for video analysis and physics modeling, electronics laboratory kits for building resistor circuits, access to MATLAB software license for data processing and analysis.

Method(s) of Evaluation

Methods of Evaluation may include but are not limited to the following:

Written laboratory reports
Demonstration of skill in handling physical laboratory equipment
Written examination on course content
Presentation of solutions to problems

Method(s) of Instruction

Methods of Instruction may include but are not limited to the following:

Students will work with laboratory partners to collect and analyze experimental data
Students will actively participate in discussion of experimental and model design
Students will engage in model verification and validation
Students will create and debug software to support modeling process

Representative Text(s) and Other Materials

Anton, H., C. Rorres, and A. Kaul. Elementary Linear Algebra: Applications Version, 12th ed.. 2019.

Elden, L.. Matrix Methods in Data Mining and Pattern Recognition, 2nd ed.. 2019.

Anderson, J.A., and M.V. McCusker. "Make the eigenvalue problem resonate with our students." PRIMUS, 29 (2019), no. 6, pp. 625-644. https://doi.org/10.1080/10511970.2018.1484400

Kalman, D. "The SVD: A Singularly Valuable Decomposition." The College Mathematics Journal, 27 (1): 2-23, January 1996. https://doi.org/10.1080/07468342.1996.11973744

Kalman, D. "An Undetermined Linear System for GPS." The College Mathematics Journal, 33 (5): 384-390, 2002. https://doi.org/10.1080/07468342.2002.11921968

Pankavich, S., and R. Swanson. "Principal Component Analysis: Resources for an Essential Application of Linear Algebra." PRIMUS, 25:5 (2015), pp. 400-420. https://doi.org/10.1080/10511970.2014.993446

Types and/or Examples of Required Reading, Writing, and Outside of Class Assignments

1. Preparation of notebooks detailing work to document process of creating a mathematical model using linear algebraic techniques
2. Create, use, and/or debug software tools for data analysis
3. Data analysis and written interpretation of resulting conclusions

Discipline(s)

Mathematics