# Course Outline of Record

**Los Medanos College  2700 East Leland Road  Pittsburg CA 94565  (925) 439-2181**

**Course Title: Calculus and Analytic Geometry III  Subject Area/Course Number: MATH-070**

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**New Course** ☐  OR **Existing Course** ☒

**Instructor(s)/Author(s)**: R. Pedersen, S. Johnson, J. De Stefano

**Subject Area/Course No.: MATH-070**  **Units: 4**
**Course Name/Title: Calculus and Analytic Geometry III**
**Discipline(s): Mathematics**

**Pre-Requisite(s): MATH-060 or the equivalent**

**Catalog Description**
Math 70 is an extension of differential and integral calculus and coordinate geometry to functions of more than one variable. Topics include: Vectors in two and three dimensions; analytic geometry of three dimensions; partial differentiation; multiple integrals; line and surface integrals; Green's Theorem, Stokes' Theorem, and applications to various fields. This course is intended for students in mathematics, science and engineering majors. Use of a mathematical software package or graphing calculator is required.

**Schedule Description**
This course is the third of the three semester calculus sequence. It extends the ideas of the previous calculus courses to three dimensions and functions of more than one variable. Applications are made to various fields including physics, engineering, biology, and social science. This course is required for math, science and engineering majors. Use of a mathematical software package or graphing calculator required.

**Hours/Mode of Instruction:** Lecture 72 *(Weekly hours)* Lab 36 Composition ____ Activity ______ Total Hours 108 *(Total for course)*

**Credit** ☒ Credit Degree Applicable (**DA**)
☐ Credit Non-Degree (**NDA**)
(If Non-Credit desired, contact Dean.)

**Grading** ☐ Credit/Non-Credit (**CR/NC**)
☐ Letter (**LR**)
☒ Student Choice (**SC**)

**Repeatability** ☒ 0
☐ 1
☐ 2
☐ 3

**Please apply for:**
**LMC General Education Requirement:** Language and Rationality: Communication and Analytical Thinking

**Transfer to:** ☒ CSU ☒ UC ☒ IGETC
XLDTP **Course is Baccalaureate Level:** ☒ Yes ☐ No

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**Course Title: Calculus and Analytic Geometry III    Subject Area/Course Number: MATH-070**

**Signatures:**

Department Chair ______________________ Date ______________

Librarian ______________________ Date ______________

Dean/Sr. Dean ______________________ Date ______________

Curriculum Committee Chair ______________________ Date ______________

President/Designee ______________________ Date ______________

CCCCD Approval Date (Board or Chancellor's Office) ______________ Date ______________

**FOR OFFICE OF INSTRUCTION ONLY. DO NOT WRITE IN THE SECTION BELOW.**

**Begin in Semester** ______________

**Dept. Code/Name**: ______________

**ESL Class:** ____Yes / No__________

**Class Code**
- ☐ A Liberal Arts & Sciences
- ☐ B Developmental Preparatory
- ☐ C Adult/Secondary Basic Education
- ☐ D Personal Development/Survival
- ☐ E For Substantially Handicapped
- ☐ F Parenting/Family Support
- ☐ G Community/Civic Development
- ☐ H General and Cultural
- ☐ I Occupational Educational

**Catalog year** 20____/20_____

**T.O.P.s Code:** ____________

**DSPS Class:** ____Yes / No_____

**SAM Code**
- ☐ A Apprenticeship
- ☐ B Advanced Occupational
- ☐ C Clearly Occupational
- ☐ D Possibly Occupational
- ☐ E* Non-Occupational
- ☐ F Transfer, Non-Occupational

*Additional criteria needed
- ☐ 1 One level below transfer
- ☐ 2 Two levels below transfer
- ☐ 3 Three levels below transfer
- ☐ 3+ Four levels below transfer

**Class Max:** ______________

**Crossover course 1/ 2:** ____________

**Coop Work Exp:** ___Yes / No_____

**Remediation Level**
- ☐ ES Elementary and Secondary Basic Skills
- ☐ P Pre-collegiate Basic Skills
- ☐ B Basic Skills
- ☐ NBS Not Basic Skills

**Course approved by Curriculum Committee as Baccalaureate Level:** _Yes / No_

**LMC GE or Competency Requirement Approved by the Curriculum Committee:** ______________

Distribution: Original: Office of Instruction
Copies: Admissions Office, Department Chairperson
Rev 10-2008

## Institutional Student Learning Outcomes

☐ **General Education SLOs (Recommended by GE Committee)**
At the completion of the LMC general education program, a student will:
1. read critically and communicate effectively as a writer and speaker.
2. understand connections among disciplines and apply interdisciplinary approaches to problem solving.
3. think critically and creatively
4. consider the ethical implications inherent in knowledge, decision-making and action.
5. possess a worldview informed by diverse social, multicultural and global perspectives.

(Each of the above student learning outcomes for the general education program has a written explanation with illustrations and examples of its application within courses, as well as specific assessment criteria. Consult the GE program information pages.)

☒ **None of the Above**

## Program-Level Student Learning Outcomes (PSLOs)

**Students completing transfer-level math courses at LMC will demonstrate:**

1. **Preparation and Mathematical Maturity:** Be prepared for the mathematical or statistical reasoning required in upper division work in their major, including the ability to generalize mathematical concepts and comprehend increasing levels of mathematical abstraction.

2. **Mathematical Literacy:**
   Communicate using mathematics:
   a. Read with comprehension documents having mathematical content and participate cogently in discussions involving mathematics;
   b. Clearly articulate mathematical information accurately and effectively, using a form, structure and style that suit the purpose (including written and face-to-face presentation).

3. **Problem-solving ability:**
   a. Reason with and apply mathematical concepts, principles and methods to solve problems or analyze scenarios in real-world contexts relevant to their major;
   b. Use technology effectively to analyze situations and solve problems;
   c. Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.

4. **Modeling ability:**
   a. Construct and interpret mathematical models using numerical, graphical, symbolic and verbal representations with the help of technology where appropriate in order to draw conclusions or make predictions;
   b. Recognize and describe the limits of mathematical and statistical methods.

**5. Effective Learning skills:**
   a. Independently acquire further mathematical knowledge without guidance, take responsibility for their own learning, determine appropriateness and correctness of their own work and function effectively in different learning environments.
   b. Succeed in different learning environments, particularly in a group setting of working collaboratively with others.

## Course-Level Student Learning Outcomes (CSLOs):

**Calculus Literacy (PSLOS 1, 2 and 5)**

CSLO 1: Students will be able to articulate the concepts of multivariate calculus, justify claims by citing course concepts, and evaluate both their own mathematical conclusions and those of classmates.

**Multi-Dimensional Generalization (PSLOS 1, 2 and 5)**

CSLO 2: Students will analyze and apply the mathematical concepts that arise when generalizing from two dimensions to three or higher and interpret how these concepts arise from the increased complexity associated with these generalizations.

**Representation and Problem Solving (PSLOS 2, 3, and 4)**

CSLO 3: Given functions of multiple variables in different representations, students will be able to select and apply appropriate strategies to solve problems in multiple dimensions, and use technology and other independent representations to verify the accuracy of their solutions.

**Calculus Applications and Analysis (PSLOS 3, 4 and 5)**

CSLO 4: Students will be able to apply multi-dimensional and vector calculus concepts to create and justify appropriate models of realistic (including scientific) scenarios, and determine the appropriate contextual interpretation and plausibility of their solutions.

## Assessments:

**CSLO 1: Calculus Literacy**
To demonstrate calculus literacy, students will complete lab assignments that require them to analyze the use of calculus in realistic contexts and applications to scientific research. To demonstrate calculus literacy on exam questions, students will justify their claims using appropriate course concepts.

**CSLO 2: Multi-Dimensional Generalization**
To demonstrate the ability to generalize to higher dimensions, students will complete regular homework and lab assignments in which they will relate how new notions in higher dimensions tie in with the analogs in lower dimensions and vice-versa (e.g. relating tangent lines to tangent planes or relating the fundamental theorem to its various three dimensional analogs). This CSLO may also be assessed as a part of the students' projects.

**CSLO 3: Representation and Problem Solving**
To demonstrate the ability to analyze and create representations, regular homework and lab assignments will contain a variety of representations (for example, instead of being given an equation, students will be asked to analyze graphs such as contour diagrams or 3D plots, a series of tabular data representing a three dimensional function, or a verbal description) and require students to construct different representations. This CSLO may also be assessed through exam questions that require graphical, numerical, algebraic and verbal descriptions of raw data or a descriptive realistic scenario. To demonstrate the ability to use a generalized problem solving process, regular homework, lab assignments and exam questions will prompt students for explanations of reasoning and process. The professor may also assign an end of the semester project to evaluate student use of an extended and iterative problem solving process.

**CSLO 4: Calculus Applications and Analysis**
To demonstrate the ability to apply multi-dimensional and vector calculus concepts to create appropriate models of realistic and scientific scenarios, regular homework and lab assignments will include authentic data and scenarios to engage students and generate realistic applications of calculus. This CSLO may be assessed through exam questions that require constructing of models and inferring conclusions based on computation of partial or directional derivatives, multiple integrals, line integrals, flux, divergence, curl etc. in earlier parts of the question. This CSLO may also be assessed through an end of the semester project that requires students to apply knowledge of derivatives to solve an optimization scenario, knowledge of multiple integrals to solve a statistical or physical application (e.g. modeling with a probability density function or finding the mass or volume of an object), or knowledge of vector calculus to model and solve a reasonably sophisticated physical problem.

**Sample Exercise for Calculus Applications and Analysis:**
For the annual cleaning, water is pumped out of the LMC swimming pool using a cylindrical pipe whose radius is 3 cm. The velocity of the water as it flows through the pipe is a function of its distance, r, from the center of the center of the pipe and is given by v(r) = 4 – 4/9 r^2 cm/sec. Calculate the rate that the water is being pumped out in cubic centimeters per second.

| CSLO | Assessment Instruments | | | | |
|---|---|---|---|---|---|
| | A. Homework | B. Lab Assignments | C. Short Projects and Presentations | D. Quizzes (optional) | E. Exams |
| 1 Calculus Literacy | x | x | x | x | x |
| 2 Dimensional Generalization | x | x | x | | |
| 3 Representation and Problem Solving | x | x | x | x | x |
| 4 Applications and Analysis | x | x | x | x | x |

## Method of Evaluation/Grading

Homework and lab assignments will be assigned on a regular basis and there will be at least two exams in addition to a final. Professors have the option to give quizzes and/ or short homework based quizzes. Students will complete extended problem solving scenarios via lab assignments and/or project(s).

Students will receive regular feedback on their progress toward course SLOs prior to major exams or projects. Feedback may include professor's written feedback, short quizzes, self- or peer-assessment.

Department policy requires that a final exam be weighted at least 20% of the course grade. Here are suggested guidelines for weighting the other assessments:

| | |
|---|---|
| Homework and Lab Assignments | 10-30% |
| Quizzes | 10-20% |
| Exams | 30-55% |
| Project (preferably in groups) | 5-20% |
| Final Exam | at least 20% |

Suggested guidelines for weighting CSLO based assessments:
CSLO 1: 20 – 30%
CSLO 2: 10 – 15%
CSLO 3: 25 – 40%
CSLO 4: 20 – 30%

A-level student work is clear, accurate, precise and well-reasoned. The work is complete, comprehensive and well-organized. The concepts, terminology and methods of multivariate calculus are applied effectively in solving problems and answering questions. Single variable calculus concepts and techniques are appropriately generalized into new settings and used effectively to solve in depth application problems. The A-level solution distinguishes relevant from irrelevant information, recognizes questionable assumptions and clarifies key concepts. The A-level solution displays a carefully reasoned process from clearly stated facts and accurately identifies logical implications and consequences. Models of realistic and scientific scenarios are created appropriately and the proper theorems are applied to solve the problems. The solutions in the work and the implications of these solutions are given clearly in context. An A-level solution documents self reflection and accurately assesses the reasonableness of the results.

C-level student work contains some clarity, accuracy, and precision but could be better reasoned. It displays insight but may at times overlook some details. Terms and distinctions are learned at a level which implies the beginning of, but not in depth comprehension of, more complicated concepts and methods. There is evidence of knowledge of the need to generalize previously used techniques and concepts into a new setting, but may perform this generalization in way that demonstrates minor conceptual flaws. Procedural calculations such as vector calculations, changes of variables, partial derivatives, multiple integrals, etc. are performed accurately at least 70% of the time. The C-level solution mostly distinguishes relevant from irrelevant information, mostly recognizes questionable assumptions, and mostly clarifies key concepts. A C-level solution displays a mostly well reasoned process and inconsistently identifies implications. Models of realistic and scientific scenarios are created appropriately at least 70% of the time and proper theorems are used to solve problems most of the time. The solutions in the work are given in context, but the implications of these solutions may be inconsistently clear. The C-level solution documents self reflection inconsistently but accurately assesses the reasonableness of the results at least 70% of the time.

## Course Content:

**Modeling Tools in Several Dimensions:** (16 hours or 4 weeks of an 18 week semester)

- Understanding real-valued functions of several variables in algebraic, tabular, and graphical form (level curves and surfaces, etc.)
- Graphing functions using contour diagrams
- Modeling with rectangular, spherical, and cylindrical coordinates
- Working with vectors and their operations (dot product, cross product, etc.)
- Constructing and using vector fields
- Constructing and using parametric representations of curves (including lines) and surfaces (including planes)

**The Derivative/Rate of Change in Several Variables:** (8 hours or 2 weeks of an 18 week semester)

- Limits, continuity, and properties of limits and continuity in several variables
- Calculating partial derivatives either algebraically, by using graphical representations (contour plots, etc.), or by using tables and interpreting these values in context
- Calculating and interpreting gradients and directional derivatives in the plane and in three dimensional space
- Calculating and interpreting second-order partial derivatives
- Applying the chain rule to functions in several variables

**Applications and Usage of Partial Derivatives and Gradients:** (8 hours or 2 weeks of an 18 week semester)

- Finding tangent planes and modeling using local linearity
- Finding local and global extrema, and saddle points,
- Solving optimization problems
- Using Lagrange multipliers to solve constrained optimization problems

**Integration of Functions of Several Variables:** (12 hours or 3 weeks of an 18 week semester)

- Finding or approximating definite integrals using graphical and tabular representations of functions of more than one variable
- Understanding and applying the use of iterated integrals to evaluate double and triple integrals algebraically
- Calculating arc length and curvature in several variables
- Evaluating double integrals using regions described by rectangular, polar, spherical, and cylindrical coordinates
- Integrating real-valued functions over surfaces
- Using the Jacobian to perform appropriate changes of variables necessary to solve application problems involving multiple integrals

**Vector Calculus:** (20 hours or 5 weeks of an 18 week semester)

- Vector-valued functions and their derivatives and integrals, including finding velocity and acceleration
- Tangent, normal and binormal vectors
- Development, computation, and interpretation of line integrals and their applications (problems that involve work, circulation, ect.)
- Understanding and demonstrating conservation of vector fields and finding potential functions
- Solving application problems in non-conservative vector field settings (using the scalar curl and Green’s Theorem)
- Using flux to solve application problems modeled by parameterized surfaces or rectangular, spherical, or cylindrical coordinates.
- Development and computation of divergence, and using the divergence theorem to solve application problems modeled using vector fields
- Development, computation, and interpretation of the curl, and using Stokes’ Theorem to solve application problems modeled using vector fields

**End of Semester Project (Optional):** (4 hours or 1 week of an 18 week semester)

- Preferably in groups, students will be assigned in-depth scenarios to solve and present solutions or write a detailed report.
- Students may observe in-class one another's project presentations, with the possibility of peer review assignments written into the project design.

## Instructional Methods:

☒ Lecture
☒ Lab
☐ Activity
☒ Problem-based Learning/Case Studies
☒ Collaborative Learning/Peer Review
☒ Demonstration/Modeling
☐ Role-Playing
☒ Discussion
☐ Computer Assisted Instruction
☒ Other (explain): Use of technology: Mathematica, Graphing Calculators, Java Applets

As a capstone calculus course, there should be a focus on advanced applications and proofs. At the beginning of each unit, the instructor may choose to introduce a real-life problem (or difficult theoretical proof) that students will work through as they learn new material.

Lecture hours will consist of the introduction of new calculus concepts by the professor, practice in group work of new calculus concepts and reinforcement of existing calculus material, student presentation of selected calculus questions to show mastery, and (optional) discussion of in-class activities.

During lecture, the professor's role is to communicate the new topics through lecture, interaction with groups and class discussion in a manner that reinforces and supports the students' existing knowledge of calculus. Additionally, the professor's role is to support and encourage students in developing independent problem solving and critical thinking skills while introducing them to sometimes unfamiliar contexts where the material is used to solve problems and guide them toward drawing appropriate conclusions regarding the use and interpretation of calculus in these contexts.

Lab hours by arrangement will consist of lab assignments more theoretical and conceptual than homework assignments, completion of which requires instruction in the Math Lab. Lab assignments typically include more in-depth and exploratory questions than homework assignments, and applications of calculus to specific fields or analysis of difficult theoretical proofs.

During lab hours by arrangement, the professor's role is to use the Socratic method to question students to stimulate mathematical thinking and support students in drawing the correct conclusions. When needed, the professor should provide one to one instruction in conceptual areas the student is misunderstanding. By the end of the semester, the student should have an increased independence in problem solving within the calculus context.

## Textbooks:

*Calculus*, Hughes-Hallett, Gleason, McCallum, et al. (2012)

*Calculus: Early Transcendentals*, Stewart (2012)