

MAPLE FOR MULTIVARIATE CALCULUS LABORATORY EXPLORATIONS AND STUDENT PROJECTS

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On-line version of this document with links for all Maple worksheets referred to in this minicourse:

<http://www.saintjoe.edu/~karend/ICTCMPresentation/MapleMultivariateCalculus.htm>

Outline of Workshop

1. Introduction, Assessment of Participants' Experience with Maple
2. Overview of How Maple enhances the student's learning in Multivariable Calculus
3. Illustration and practice with major features for Multivariable Calculus through example Maple worksheets for the classroom
4. Student Multivariable Calculus Projects in Maple

Introduction

I have been teaching our second year (Calculus III and IV) for the last 13 of my 27 years at Saint Joseph's College. I first became acquainted with Maple at one of the very early ICTCM conferences. We first adopted Maple V to use in Calculus and other higher level courses. We are using Maple 12 this year and will likely upgrade versions next year. The Calculus III and IV classes meet three times a week. One of those three meetings is in a computer lab. During the other two class times, we are in a regular classroom equipped with a computer with Maple, and projection.

The four primary areas where we have seen advantages in using Maple for our second year calculus are:

Visualization: The powerful graphing features of Maple facilitate connecting theory and computation with geometric interpretation. For example, relationships between surfaces, level curves, and gradient vectors can be easily explored.

Computation: For some concepts, such as tangent and normal vectors, computations can be very cumbersome and thus interfere with conceptual understanding. Maple can remove the drudgery of the computations, allowing students to focus on theory, methods, and applications.

Assignment Verification (Checking Answers): We still want our students to be able to carry out computations (show work!). However, Maple can perform the step by step calculations as well, giving the students a chance to check their work and find their errors.

Independent Exploration and Student Projects: Maple's interface allows students to explore *and* write about concepts within the same document. They can easily edit their Maple commands as well as their accompanying writing. Maple 2D math encourages student to write their mathematics with correct mathematical notation. For projects, the interactive style of the software allows students to start by implementing a scaled-back portion of a project idea, then iteratively expand upon that idea. By using Maple's help facilities with instructor's advice and trouble-shooting, students can develop projects that are really fun as well as educational.

At our annual Saint Joseph's College Undergraduate Colloquium, Calculus IV students have been presenting their projects in an informal walk-through "poster session". This format gives them a chance to explain their work to their peers and appreciative faculty in very creative ways. Traditionally they have shown their Maple worksheet interactively along with creative posters or a slide show presentation. They often have a fun activity for the attendees. Some of the memorable activities include:

- For a project on knot theory, small groups practiced forming "human knots".
- A "Match Game": Participants matched pictures of gradient fields, contour plots, and surfaces.
- Interactive Roller Coaster Design: Attendees varied parameters for their own roller coaster design.

Pictures from Last Year's Colloquium

Resources for assistance with Maple for Multivariable Calculus

Maple is a real power tool, which means it requires an investment of time to learn to use its features effectively. Then -- as soon as one starts to feel comfortable -- an upgrade is released with new features to master. Some of the helpful resources for keeping up are:

- Maplesoft.com web site <http://www.maplesoft.com>:
 - Application Center Contributed Maple Applications -- Many pertinent to Multivariable and Vector Calculus. The Classroom Tips and Techniques are particularly useful.
- Within Maple software:
 - Maple Portal -- Choose Help-Manual, Resources, and More -- Maple Portal. This serves as a starting point with tutorials on topics and a special portal link for Math Educators.
 - Online Help: From the Help menu, select Maple Help, Enter your topic name to search online help on topic.
 - Maple Example Worksheets: Under Help-Manual, Resources, and More -- Applications and Examples -- Scroll down to Examples and click on Examples/index
 - Tasks and Tutors (See end of this handout). These can help you learn the syntactic features of Maple while you are using them to solve problems.

Multivariable Maple Calculus Labs for Students -- Examples with Exercises and Solutions

A. Space Curves and Vector Valued Functions in Maple

- Basics of Plotting Vector valued functions as curves in space:
Maple Worksheet: [SpaceCurves.mw](#) Answers: [SpaceCurves-ans.mw](#)
- Velocity, Acceleration, and Projectile Motion
Maple Worksheet: [PositionVelocityAcceleration.mw](#)
Answers: [PositionVelocityAcceleration-ans.mw](#)
- Unit Tangent and Principal Unit Normal
Maple Worksheet: [TangentNormal.mw](#) Answers: [TangentNormal-ans.mw](#)
- Arc Length and Curvature
Maple Worksheet: [ArcCurvature.mw](#) Answers: [ArcCurvature-ans.mw](#)

B. Functions of Two or Three Variables in Maple

- Functions of Two Variables: Plotting and Analyzing Limits
Maple Worksheet: [Fcns2Vars.mw](#) Answers: [Fcn2Vars-ans.mw](#)
- Gradient Vectors and Level Curves
Maple Worksheet: [GradientLevelCurves](#) (No exercises to complete)
- Extreme Values (2nd Derivative Test)
Maple Worksheet: [ExtremeValues.mw](#) Answers: [ExtremeValues-ans.mw](#)
- Lagrange Multipliers
Maple Worksheet: [LagrangeMult.mw](#) Answers: [LagrangeMult-ans.mw](#)

C. Multiple Integration in Maple

- Double Integrals (Rectangular and Polar), Center of Mass
Maple Worksheet: [DoubleInt.mw](#) Answers: [DoubleInt-ans.mw](#)
- Triple Integrals in Spherical Coordinates
Maple Worksheet: [TripleIntSpherical.mw](#) Answers: [TripleIntSpherical-ans.mw](#)

Some Options in Maple 13 Not Explored in above Worksheets

Maple Tasks

A Maple task is a template that assists in performing a specific task, such as: determining the directional derivative of a function of several variables.

This can be accomplished by the following steps:

- Choose Tools - Tasks -Browse
- Then from the menu on the left select Multivariate Calculus and Directional Derivative --
- Select Insert into a new worksheet.
- Select Insert Default Content.
- The following example worksheet contains the results:
[TaskTemplateExample.mw](#)

Maple Tutors

Using the Tutors menu from Maple you can invoke interactive Maplet applications. As an example you can invoke the Maplet that explores directional derivatives by doing the following:

- From the Tools menu, select Tutors, Calculus - Multi-Variable, and then Directional Derivatives.

Calculus IV Colloquium Projects

This Year's Calculus IV Projects are underway (The Colloquium is in April). The topics for this year's projects selected by students include:

1. Projectile Motion of a Baseball in 3D with Wind and Batting Angles --
Exploring what it takes to be a home run under varying conditions.
2. Modeling Parametric Surfaces and Calculating Surface Area – Exploring what it takes to frost a donut.
3. Modeling Planetary Motion with Vector Valued Functions.
4. Exploring the Geometry of Icosahedrons.

Below are links to the project assignment description and information about the colloquium where students will be giving their poster presentations.

- Current Project Description and Timeline:
<http://www.saintjoe.edu/~karend/m236/m236projects-092.html>
- Saint Joseph's College Undergraduate Colloquium 2010 Link:
<http://www.saintjoe.edu/academics/colloquium/>

Sampling of Past Projects

1. Brian McLeish and Crystal Stines: *Manufacturing and Production: Exploration of the Cobb-Douglas Formula*

[Maple Worksheet](#) [Power Point](#)

2. Kyle Rush: *Clothoid: The Supreme Equality Curve*

[Maple Worksheet](#) [Picture of Poster](#)

3. Ishan Gohin and Jason Polomchak: *The Deltoid Curve*

[Maple Worksheet](#) Pictures: [Poster](#) [Presenting](#)

4. Kyle Fender and Abigail Edwards: *Tumor Volume with Spherical Coordinates*

[Maple Worksheet](#) [PowerPoint](#)

5. Danny Livarchik and Stephanie Storer: *Witch of Agnesi*

[Maple Worksheet](#)

6. Mike Koscielny: *Puma Lettering with Space Curves*

[Maple Worksheet](#)

[Slide Show](#) of A Few Pictures from last year's Colloquium

Please contact me with any comments, suggestions, or sharing of ideas at the email given at the beginning of this paper.